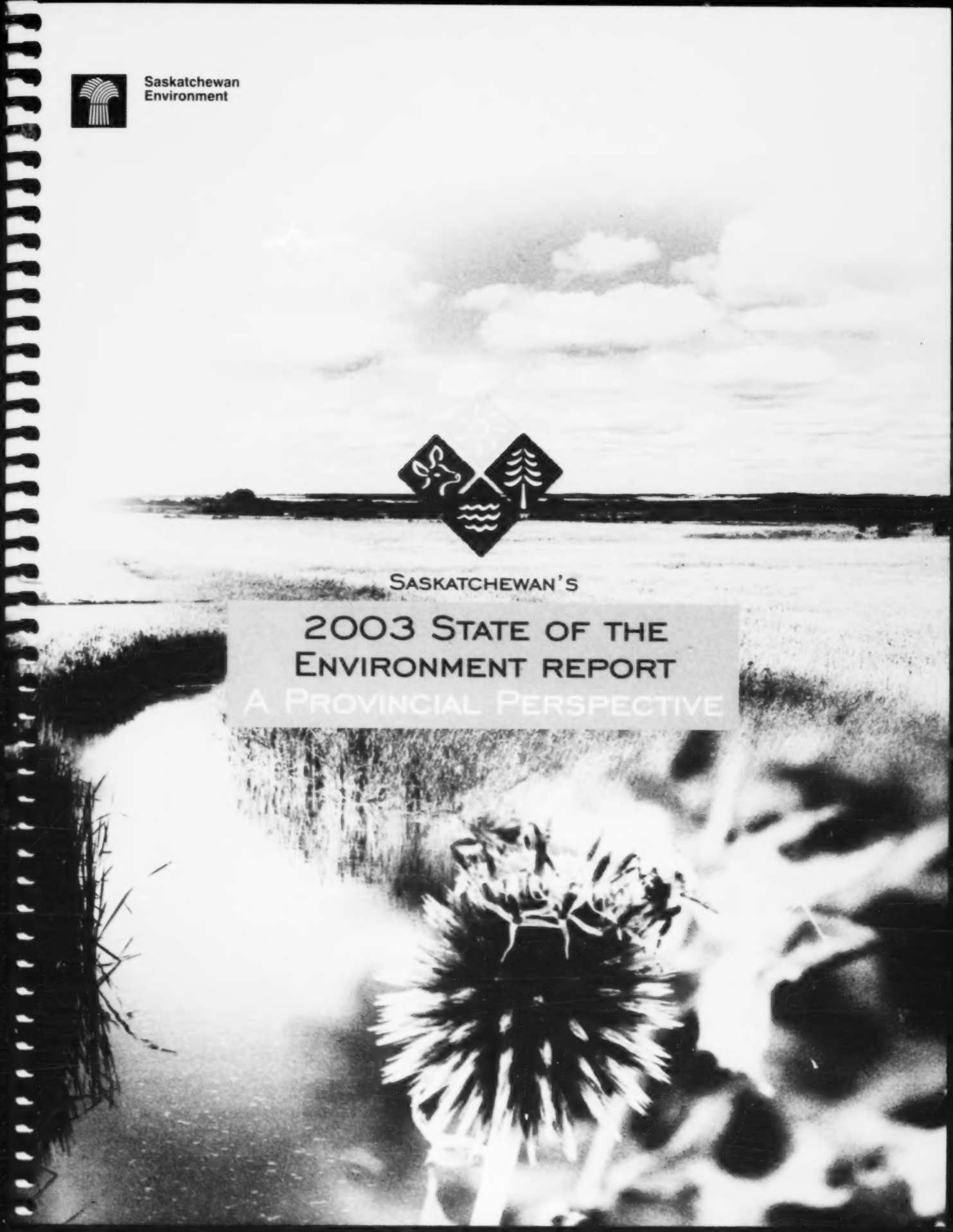
Saskatchewan
Environment

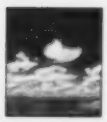


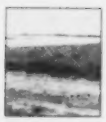
SASKATCHEWAN'S

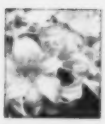
2003 STATE OF THE ENVIRONMENT REPORT

A PROVINCIAL PERSPECTIVE

Letter of Transmittal







April 2003

Dear Reader:

Our physical, social and economic well-being depends on a healthy environment. Each one of us has a role to play in protecting the environment. The realization that the health of our environment is a responsibility shared by all of us is changing peoples' attitudes and behavior.

We are aware that the "footprints" of overuse on certain parts of our environment are evident and that historically we have not had adequate respect for the environment. However, we are now working to understand the results of stresses to the environment in order to achieve a sustainable future.

This is Saskatchewan's seventh State of the Environment report. It provides information on current environmental trends, conditions and emerging issues. Key activities impacting the environment are discussed, as well as initiatives undertaken in response to these stressors.

I hope you find the information contained in this report interesting and useful. Any suggestions or opinions you may have to make these reports more useful are welcomed.

Yours sincerely,

Buckley Belanger
Minister
Saskatchewan Environment

103-04228/

Preface

State of the Environment (SOE) reports are intended to inform the Saskatchewan public of the condition of the province's natural environment and resources. The reports provide available scientific and descriptive data to reveal how well the province is moving toward sustainable development. Sustainable development, which first gained prominence at the United Nations World Summit of 1992, is the result of social and economic development that considers the needs and values of all interested parties, while maintaining future options and conserving natural resources and diversity.

This SOE report is the seventh in a series of reports that began in 1991, initiated by *The State of the Environment Report Act, 1990*, which requires that Saskatchewan prepare such a report once every two years. The last four SOE reports individually focused on one of the province's four ecozones: the Boreal Plain Ecozone (1995); the Prairie Ecozone (1997); the Boreal Shield Ecozone (1999); and the Taiga Shield Ecozone (2001). *Saskatchewan's State of the Environment Report 2003 - A Provincial Perspective* provides information for the entire province.

The 2003 report focuses on the relationship between human activities and the condition of the environment in Saskatchewan. The report does not present an exhaustive description of all environmental trends and conditions throughout the province, but presents key information based on current studies and monitoring that is available at the time of print. Work is ongoing to better monitor environmental trends and better understand the complex relationship between human actions and environmental change.

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In particular, we are indebted to the State of the Environment Report Steering Committee, representing a wide variety of provincial and federal departments who contributed to, edited, reviewed and assisted with the production of this document.

2003 Saskatchewan State of the Environment Report Steering Committee:

- Canadian Nuclear Safety Commission
- Department of Indian and Northern Affairs Canada
- Environment Canada
- Prairie Farm Rehabilitation Administration
- Saskatchewan Agriculture, Food and Rural Revitalization
- Saskatchewan Government Relations and Aboriginal Affairs
- Saskatchewan Highways and Transportation
- Saskatchewan Industry and Resources
- Saskatchewan Northern Affairs
- Saskatchewan Tourism Authority
- Saskatchewan Watershed Authority
- SaskPower

We also thank Mr. Wayne Pepper of JWJ Associates, Regina for his assistance in finalizing the report.

Special thanks to Paul Geraghty for his illustrations that greatly enhanced this report.

Many Saskatchewan Environment staff contributed to every chapter of this report. Their efforts, as always, are appreciated and acknowledged.

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Introduction

Saskatchewan residents receive many benefits from the environment and its resources. These resources include more than tangible commodities such as timber, minerals and oil, but also include ecological services that provide clean air, pure water and productive soils. Natural ecosystems provide the basis for all life and increasingly around the world it is realized that the degradation of these systems for short-term gain can lead to long-term problems for humans.

The extent of human impacts on Saskatchewan's environment varies from north to south. In the northern half of the province, large tracts of pristine wilderness remain undisturbed, since the area has experienced limited development, with the exception of some mining operations and scattered northern communities. Central areas of the province also maintain some pristine, forested wilderness, although commercial forestry is impacting the landscape and greater human settlement exists. Southern Saskatchewan has changed most fundamentally, as the majority of prairie grasslands have been converted to cropland, and human communities have been established throughout the region.

Over the past few years, management of the environment in the province has been gradually changing. An ecosystem-based management approach is being promoted, which involves efforts to better understand the province's ecosystems, their components and the linkages and interrelationships between them. In this way, managers are able to predict how human actions may impact or affect the natural environment and to better manage, or even prevent, problems before they occur. In addition, there is growing interest in the linkages between environmental and human health. The outbreak of *Cryptosporidium* in North Battleford in 2001 has resulted in a new awareness of the connection between safe environmental management and public health.

The State of the Environment report attempts to reflect this change in approach. Rather than focusing on specific issues or individual sectors, such as forests or wildlife, it is organized to give the reader a new perspective on the fundamental linkages between human actions and environmental quality.

The report begins by providing general information on the environment and describing different ecologically distinct areas of the province (ecozones and ecoregions). This is followed by a section on the direct social and economic benefits derived from the environment. The remainder of the document focuses on the specific environmental components of air, land, water and biodiversity. These chapters identify activities that are affecting each component, describe related environmental conditions, outline some potential risks to ecosystem and human health, and report on associated management programs and activities. Because of the way the material is organized chapters should be read in their entirety to get an accurate picture.

BACKGROUND

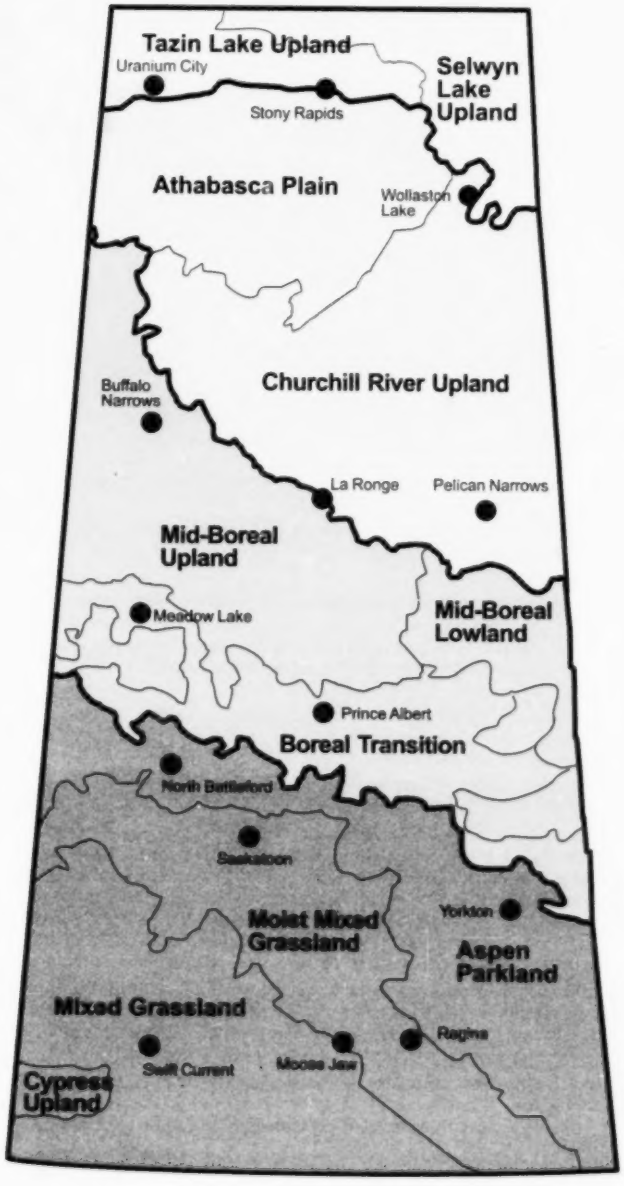


Figure 1.1 Ecozones and Ecoregions of Saskatchewan

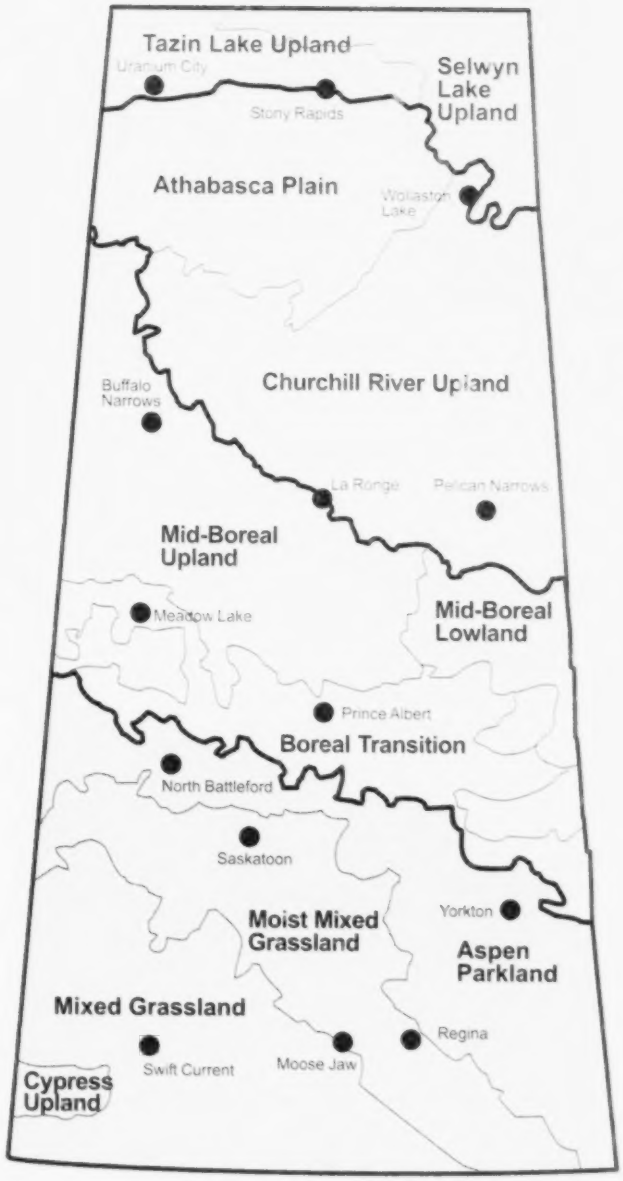
Source: Padbury and Acton, 1994

General Description of Saskatchewan's Ecozones and Ecoregions

Saskatchewan features a diversity of natural landscapes, ranging from pristine lakes and wilderness in the north, to open grasslands and picturesque valleys and coulees in the south. Landscapes change throughout the province, based on various physical and biological factors that determine the character of a region. These factors include geology, climate, soils, landforms, vegetation, and can include human activities.

It is this variation of natural landscapes, as well as the range of different human activities within these ecozones, that results in different environmental conditions and management challenges throughout the province. Environmental issues vary in their significance, depending on the region. For example, acid deposition in northern lakes may result in more serious environmental damage because the natural buffering capacity of these lakes is less than those in the south.

Ecological land classification is a way of describing landscapes. It is a process of classifying and delineating ecologically distinct areas of the province to better understand their similarities and differences. Based on the "Ecoregions of Saskatchewan" poster map, Saskatchewan's landscapes are classified into four ecozones and 11 ecoregions (Padbury and Acton, 1994). Brief descriptions of the four major ecozones in the province are presented below (from north to south) and are illustrated in Figure 1.1. More information is summarized in Appendix 1. In addition, detailed descriptions of all ecozones and ecoregions can be found in *The Ecoregions of Saskatchewan* technical report (Acton et al., 1998).



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1.1 - TAIGA SHIELD ECOZONE

The Taiga Shield Ecozone is an area of transition between boreal forest in the south and tundra in the north. About 30 per cent of the region is covered by water. This ecozone is only accessible by air, water or winter roads, and much of the area remains in a wilderness state. The ecozone is essentially a series of broad uplands and accompanying lowlands with outcrops of Precambian rock. There are many lakes and streams that flow either towards Hudson Bay or the Beaufort Sea.

The climate is characterized by low precipitation. Winters are very cold and can be seven or eight months long. Summers are short and cool with up to 18 hours of daylight per day.

The vegetation in this ecozone makes a transition from relatively dense coniferous forest in southern areas, to subarctic, fairly open woodland with black spruce, lichen and feathermoss. In very dry areas, there may be large patches with little or no vegetation. Lowland areas are composed of bogs, which may be wooded or treeless, and fens.

Ecoregions in the area include the Selwyn Lake Upland Ecoregion and Tazin Lake Upland Ecoregion.

1.2 - BOREAL SHIELD ECOZONE

The Boreal Shield Ecozone extends from Lake Athabasca on the Alberta border, south to Creighton on the Manitoba border. Water covers between 10-30 per cent of the land area, with several very large lakes and Saskatchewan's largest river, the Churchill. Much of this ecozone is dominated by broadly rolling uplands interspersed with wetlands. In the northwest, the Athabasca Basin has a subdued relief, while to the south and east, the region consists of rugged forests and many lakes that are typical of the Canadian Shield.

This ecozone has a subarctic climate. It is characterized by long, very cold winters and short, cool summers, with many hours of daylight per day.

Coniferous forests typically cover this ecozone, where soil and moisture conditions permit. The most common mature forest is black spruce forest with a ground cover of lichens. Black spruce and jack pine are found on thin sandy soils while black spruce and tamarack occur on poorly drained lowlands. Frequent fires have favored the spread of jack pine and the scattered occurrence of white birch. White spruce, balsam fir, trembling aspen and balsam poplar occur in river valleys, around lakes and on south-facing slopes.

Ecoregions in this area include the Athabasca Plain Ecoregion and the Churchill River Upland Ecoregion.

1.3 - BOREAL PLAIN ECOZONE

The Boreal Plain Ecozone extends across the province in a band from the Canadian Shield south to the aspen parkland of the Prairie Ecozone. There are numerous lakes and rivers, including the Saskatchewan River. In general, the lakes tend to be quite large and more shallow and productive than lakes in the Boreal Shield Ecozone. Most of the area is northern boreal forest, but the southern 25 per cent is used for agriculture. The terrain is flat to gently rolling with some prominent upland areas such as the Pasquia Hills. Rivers cross the plain, eventually flowing into Hudson Bay.

The climate in this ecozone varies with location. More northerly regions have a subarctic climate with long, cold and snowy winters. Summers are short, warm and moist. Precipitation is variable. Southern parts of the region have a humid continental climate.

This ecozone is covered by coniferous forests or a mixture of coniferous and deciduous trees. Conifers consist mainly of white spruce, black spruce, jack pine and tamarack. Deciduous trees include white birch, trembling aspen and balsam poplar. The proportion of conifers usually increases with cooler conditions. Peatlands are extensive with some wetlands. Floating mats of aquatic plants are characteristic along lake shores.

Ecoregions in this area include the Mid-boreal Upland Ecoregion, Mid-boreal Lowland Ecoregion and the Boreal Transition Ecoregion.

1.4 - PRAIRIE ECOZONE

Canada's Prairie Ecozone is only the northern tip of a landscape unit that reaches well into the heartland of the United States and is known internationally as the Great Plains Ecological Region of North America. In Saskatchewan, it occupies roughly the southern one-third of the province. The soils are highly productive for agriculture due to their relatively high natural fertility and good moisture-holding capacity. Waterbodies include streams and rivers of varying sizes and small wetland areas in the form of sloughs, ponds and marshes. The landscape in this ecozone is generally flat but is interspersed with areas of rolling or hilly terrain. Sand dunes, valleys, coulees, potholes and other bodies of water also are found.

The climate is characterized by short hot summers, long cold winters, low levels of precipitation and high evaporation. High winds result in soil erosion and water evaporation, as well as surface cooling (wind chill) for both plants and animals. Warm winter chinook winds extend into southwest Saskatchewan.

The vegetation consists of different grassland types including short-grass, mixed-grass and fescue prairie all combined with a variety of sedges and forbes (broad-leafed plants). Areas of shrub and aspen occur where moisture permits. Higher uplands, such as Cypress Hills and Moose Mountain, have more forested vegetation. Cypress Hills has montane vegetation dominated by lodgepole pine, and Moose Mountain has a deciduous forest, dominated by trembling aspen.

Ecoregions in this area include the Aspen Parkland Ecoregion, Moist Mixed Grassland Ecoregion, Mixed Grassland Ecoregion and Cypress Upland Ecoregion.

The Benefits of Ecosystems

2

ECOSYSTEM SERVICES

Landscapes are composed of a multitude of different ecosystems. An ecosystem is an interdependent system consisting of all living organisms in a given area, all the physical and chemical factors of the environment, and the processes that link them. Ecosystems provide essential support or services to plants, animals and human life. The more diverse and complex ecosystems tend to be, the more they are able to provide tangible goods and ecological services that benefit humans.

Ecosystem services are so fundamental to life and so large in scale that they are easy to take for granted. It is hard to imagine that human activities could irreparably disrupt them. Their complexity makes them extremely hard to mimic through technology. For example, soil organisms, which are crucial to the chemical conversion and physical transfer of essential nutrients to higher plants, are extremely varied and abundant. Under a square-yard of pasture in Denmark, for instance, the soil is inhabited by roughly 50,000 small earthworms and their relatives, 50,000 insects and mites, and nearly 12 million roundworms. A pinch of fertile soil may contain over 30,000 protozoa, 50,000 algae, 400,000 fungi and billions of individual bacteria (Daily et al., 1997).

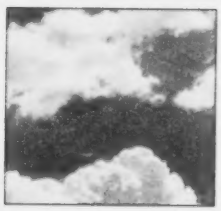
Ecosystems provide a variety of ecological services that benefit humans. Several of these key benefits are briefly described on the next page.

2.1 - ATMOSPHERIC COMPOSITION

The composition of the air is maintained by living things in ecosystems. Phytoplankton in the oceans and vegetation in the forests, grasslands and wetlands provide the perfect mixture, or balance, of oxygen, nitrogen, carbon dioxide and other gases to sustain life.

Greenhouse gases (GHGs) are also absorbed by ecosystems. Carbon dioxide is the main GHG entering the atmosphere from human activities. More than half of the carbon dioxide produced by combustion of fossil fuels does not accumulate in the air but is removed and returned to nature. Soils, oceans and forests are significant for this sequestering of carbon.

2.2 - CLIMATE REGULATION



Ecological services regulate the climate through processes so complex that they are not fully understood. They can offset the effects of climate oscillations by responding in ways that alter greenhouse gas concentrations in the atmosphere. Ecosystems also exert direct physical influences that help moderate local and regional weather.

2.3 - WATER PURIFICATION, REGULATION, SUPPLY AND FLOOD CONTROL

The regulation, supply and purification of water is performed through many ecosystem processes and components. Soil soaks up much of the rainfall and gradually distributes it to plant roots and into aquifers and surface streams. Plants and plant litter shield the soil from the destructive force of rain drops and hold it in place. Living vegetation also returns water from the ground into the atmosphere. Wetlands help to filter and conserve water as well as reduce flooding. Most wetlands are linked with groundwater and surface water supplies and help to recharge the groundwater source for wells. Approximately 90 per cent of the water supply for Saskatchewan farms comes from wells. One of the most important services of wetlands is their filtering ability, as they capture sediments and neutralize contaminants, thereby purifying water.

2.4 - SOIL SERVICES

Soils retain and deliver nutrients to plants. Diverse species of bacteria, fungi, algae, crustacea, mites, termites, springtails, millipedes and worms all contribute to the fertility of the soil. Some bacteria fix nitrogen, taking it from the atmosphere and converting it to forms usable by plants, animals and humans. Certain fungi play a role in supplying nutrients to trees. Earthworms and ants break up and mix plant and microbial material, enhancing soil stability, aeration and drainage. Soils also play a central role in the decomposition of dead organic matter and wastes, rendering harmless many potential human pathogens.

2.5 - POLLINATION

Pollinators are of enormous value to natural ecosystems and to agriculture. Without pollinators, plants cannot produce seeds that are necessary to their survival, and animal and human life. One-third of human food is derived from plants pollinated by wild pollinators. Animal pollination is required for reproduction of most flowering plants, wild plants and about 80 per cent of the agricultural crop species. Between 120,000 and 200,000 animal species perform this pollination (Abramovitz, 1998).

2.6 - PEST CONTROL

Ecosystems provide natural pest control. An estimated 99 per cent of potential crop pests are controlled by natural enemies, including many birds, spiders, parasitic wasps and flies, ladybugs, fungi, viral diseases and numerous other types of organisms. This can save farmers billions of dollars annually by protecting crops and reducing the need for chemical pest control (Daily et al., 1997).

2.7 - SEED DISPERSAL

Many seeds are dispersed by wind, and some, by water, but without thousands of animal species to disperse seeds, many plants would fail to reproduce. Animals disperse seeds by eating fruits. Some seeds require passage through the gut of an animal before they will germinate. Squirrels or birds bury seeds that germinate later. Some seeds attach themselves to animals through sticky or sharp spines. Birds open tree cones and disperse the seeds.

2.8 - AESTHETICS AND SPIRITUAL

Healthy ecosystems tend to provide a spiritual connection for humans. Nature is a source of wonderment and inspiration, peace, fulfillment and rejuvenation. Wilderness experiences improve mental and physical health, through such activities as hiking, camping, canoeing, fishing and hunting. Closer to home, bird-feeding and watching, photography and gardening improve our link with nature. These activities contribute to the economy, but also enrich our lives.

2.9 - ECOSYSTEM GOODS

The most obvious benefits provided by ecosystems include food and raw materials from natural resources. Soils grow vegetation that is a source of many types of food for all kinds of species, including humans. Many natural products are extracted from ecosystems, including gums, essential oils, flavorings, resins and waxes. Vegetation is also used for timber, fuelwood, fiber, industrial products and drugs. Most prescription drugs are based on natural compounds from plants, fungi, animals and micro-organisms, as are herbal and other natural remedies.

To place a dollar value on all these natural benefits from ecosystems is an extremely difficult task. However, one leading authority on the subject of natural capital has developed some global figures on the value of selected ecological services. Robert Constanza, from the University of Maryland's Institute for Ecological Economics has estimated that the dollar value of key ecological services on a global scale would be in excess of $33 trillion (US). This figure is based on various assumptions since there is no real hard data. However, the value may not be as important as the realization that the loss or destruction of ecological services could eventually result in phenomenal costs to replace them.

3

COMMERCIAL ECONOMY

The economic benefits of various commercial sectors dependent on the environment are described in the following sections. These sectors of the economy are those that depend most directly upon Saskatchewan's natural resources. While most of the data presented is consistent, 2001 gross domestic product (GDP) data has not been included because it is not directly comparable to 1986, 1991 and 1996 data. New accounting methods were used by Statistics Canada for 2001 to gather economic data.

3.1 - AGRICULTURE

Agriculture is one of the pillars of the Saskatchewan economy and is vital to its economic stability. Agriculture accounts for 40 per cent of the province's jobs, directly and indirectly. Saskatchewan farmers purchase more than $4 billion worth of input goods annually and produce roughly 40 per cent of the province's exports. The economic impact of agriculture and food is even broader in the province's rural areas, providing spin-off jobs and helping to keep rural communities viable.

Primary agriculture is carried out on over 26 million hectares in Saskatchewan, of which 18 million hectares are in annual crop production and approximately 8 million hectares are used for forages and livestock production. Approximately 45 per cent of Canada's arable land base is located in Saskatchewan. The *2001 Census of Agriculture* recorded 50,598 farms in Saskatchewan. The average farm size is 519 ha, and the average cultivated area on farms is 394 ha.

Saskatchewan's semi-arid climate, relatively low heat units, cold winters and highly variable weather patterns dictate the range of crops that can be grown. The province has a competitive advantage in the production of several high-quality crops. Saskatchewan is the main Canadian producer for some crops like lentils, peas and mustard. Saskatchewan's wide-open spaces, relatively inexpensive land and generally abundant supplies of feedstocks make the province an ideal location for animal production as well.

See Table 3.1 for farm income, employment figures and contribution to GDP.

Table 3.1 Agricultural Statistics in Saskatchewan

Year	Farm Cash Receipts ($ thousands)	Net Farm Income ($ thousands)	Direct Employment* ($ thousands)	Percentage of GDP
1986	4,147.5	1,185.0	96.4	9.9
1991	4,129.8	477.1	85.0	10.5
1996	5,757.0	1,358.6	72.8	8.8
2001	6,567.2	265.3	52.5	

*Footnote: *Persons deriving over 50% of their income from agriculture.*
Data Source: Saskatchewan Bureau of Statistics, 2001b; Statistics Canada.

3.2 - FORESTRY

The forestry sector has seen a gradual increase in its contribution to the Saskatchewan economy (Table 3.2). Factors such as the United States softwood lumber countervail duty and cyclical changes in world lumber prices have caused short-term variations around this slow rise. In 1986, forestry contributed $84 million to the provincial GDP, comprising 0.4 per cent of GDP. By 1996, it contributed $107 million, comprising 0.5 per cent of GDP (Saskatchewan Bureau of Statistics, 2001b). Total sales of forest products in 2001 were over $844 million (Council of Saskatchewan Forest Industries, 2001).

Table 3.2 Forestry Statistics in Saskatchewan

Year	Contribution to GDP ($ millions)*	Percentage of GDP
1986	84	0.4
1991	58	0.3
1996	107	0.5

*Footnote: *Constant 1992 dollars.*
Source: Saskatchewan Bureau of Statistics, 2001b.

The main products of Saskatchewan's forest industry are dimension lumber, pulp and paper, oriented strandboard (OSB), plywood and fence posts. Of the total provincial forest products production, the majority is exported to markets in the United States, Europe and Asia. The balance is sold in Saskatchewan and other domestic Canadian markets.

3.3 - MINING

The mining industry contributes significantly to the provincial economy. In 2000, mining created $252.7 million in royalties to the province from an annual production valued at $2.311 billion (Table 3.3). The mining industry also spent $187 million on new capital and $30.1 million on mineral exploration. Mining provided 5,285 direct jobs and an estimated 10,000-11,000 indirect jobs in Saskatchewan in 2000 (SEM, 1997, 2001).

Table 3.3 Mining Statistics in Saskatchewan

Year	Value ($ million)*	Direct Employment	Government Royalties ($ million)*	Percentage of GDP
1986	1,678.1	6,068	102.1	4.9
1991	1,431.4	5,300	97.0	5.0
1996	2,140.9	5,995	175.5	5.2
2000	2,311.0	5,285	252.7	

*Footnote: *Constant 2000 dollars.*
Sources: Saskatchewan Bureau of Statistics, 2001a,b; SEM 1997, 2001.

Saskatchewan is the world leader in the production of both potash and uranium, producing about a third of the world supply of both commodities. Coal production provides about 70 per cent of the province's power generation. There are 31 active mine and/or mill operations in the province: 10 potash, 4 uranium, 3 coal, 1 gold, 2 base metal, 3 salt, 2 sodium sulphate, 2 potassium sulphate, 1 bentonite, 2 clay, and 1 moss peat. Of all the mining operations, potash mining provides the majority of the production value, employment and government revenue (SEM 1997, 2001).

3.4 - OIL AND GAS

Oil and natural gas production is the principal industry in the province in terms of value. Saskatchewan is the second largest oil and gas producer in Canada. In 2000, the oil and gas industry provided $1.038 billion in royalties and fees to the province from an annual production valued at $6.13 billion (Table 3.4). Capital spending was $1.688 billion, and 3,605 wells were drilled. This activity provided for 8,351 direct jobs and an estimated 16,000-17,000 indirect jobs that same year (SEM, 1997, 2001).

Table 3.4 Oil and Natural Gas Statistics in Saskatchewan

Year	Value ($ million)*	Direct Employment	Government Royalties and Fees ($ million)*	Percentage of GDP
1986	1,927.2	4,515	341.0	5.6
1991	1,775.0	4,715	277.4	6.2
1996	3,691.8	7,280	796.3	8.9
2000	6,130.0	8,351	1,038.3	

*Footnote: *Constant 2000 dollars.*
Sources: Saskatchewan Bureau of Statistics, 2001b; SEM 1997, 2001.

Oil and gas production in Saskatchewan occurs in the Western Canada Sedimentary Basin in the southern portion of the province. Along the western margin, oil and gas are produced from the provincial boundary to as far north as Primrose Lake and as far east as Swift Current. Extensive oil production also occurs in the southeast corner of the province from the Williston Basin.

3.5 - COMMERCIAL FISHING AND TRAPPING

The Freshwater Fish Marketing Corporation (FFMC) sets the prices for commercial fish. As Table 3.5 demonstrates, the combination of higher production and generally higher prices for most species has resulted in enhanced income for the fishing industry.

Table 3.5 Total Value to Fishermen in Saskatchewan - Freshwater Fish Marketing Corporation Initial and Final Payments Plus Peddled Fish Revenue

Year	FFMC Initial $	FFMC Final $	Peddled $	Total to Fishermen $
1996-97	3,518,856	26,695	483,173	4,028,724
1997-98	3,397,691	265,149	303,300	3,966,140
1998-99	3,683,176	640,699	442,616	4,766,491
1999-00	4,142,817	515,704	299,257	4,957,778
2000-01	4,099,705	849,249	332,106	5,281,060
2001-02	4,358,131	743,456	400,000	5,501,587

Source: Maher, 2002.

Commercial fishing and trapping contributed approximately $4.3 million to the provincial economy in 2001 (Alain, 2002). Commercial trapping involves the harvesting of the arctic fox, badger, bear, beaver, bobcat, coyote, fisher, cross fox, red fox, silver fox, lynx, marten, mink, muskrat, otter, raccoon, skunk, squirrel, weasel, wolf and wolverine. The total number of pelts accumulated each year varies significantly. There were 409,930 pelts gathered in 1986-87, while in 2000-01, only 87,209 pelts were gathered. The total dollar value of all pelts gathered in the province was $7.6 million in 1986-1987 and $1.9 million in 2000-01 (Barton, 2002). See Table 3.6 for the economic value of trapping.

Table 3.6 Trapping Harvest (Pelts) and Economic Value in Saskatchewan

Year	Total Pelts*	Total Value ($)
1986-87	409,930	7,577,294
1991-92	93,447	1,670,658
1996-97	203,403	2,990,892
2000-01	87,209	1,910,908

*Footnote: *Includes arctic fox, badger, bear beaver, bobcat, coyote, fisher, cross fox, red fox, silver fox, lynx, marten, mink, muskrat, otter, raccoon, skunk, squirrel, weasel, wolf and wolverine pelts.*
Source: Barton, 2002.

3.6 - TOURISM

Tourism is the fourth-largest and fastest-growing industry in the province. In 2001, tourism in Saskatchewan generated more than $1.3 billion dollars in travel spending. In that same year, about 60,000 people (or one in every 10 workers) were employed in tourism-specific and tourism-related jobs in Saskatchewan. More than half of these jobs are outside the major centres of Regina and Saskatoon, and over 35 per cent are in rural areas and in the north. Increasingly, travellers are seeking nature-based experiences, reinforcing the need for environmentally sustainable tourism development.

3.6.1 - Outdoor Recreation

The Saskatchewan economy benefits greatly each year from residents and non-residents involving themselves in nature-related activities. These activities include hiking, canoeing, camping, wildlife viewing, sport hunting and fishing. Nature-related expenditures include the cost of accommodation, transportation, food, equipment such as camping gear, and other items, such as donations to nature-related organizations.

Most data reported here was derived from the *Survey on the Importance of Nature to Canadians*, which is conducted every five years by a partnership of 16 federal, provincial and territorial government agencies, led by Environment Canada. Data for 1996, the most recent year available, was collected from a sample of approximately 87,000 Canadians (Environment Canada, 2000).

Nature-related expenditures in Saskatchewan have dramatically increased from 1991 to 1996, as totals have changed from $172.3 million to $387.8 million (Table 3.7). The employment created from nature-related expenditures has also increased from 4,002 jobs in 1991 to 7,800 jobs in 1996. Expenditures on outdoor activities in natural areas (non-consumptive activities) have increased most dramatically from $76.7 million in 1991 to $263.7 million in 1996. Those who participated in outdoor activities in natural areas spent an average of $763 on these activities in 1996. This was the third highest average expenditure of all the provinces (Environment Canada, 1994, 2000).

Table 3.7 Economic Benefits of Nature-Related Activities in Saskatchewan

Year	Outdoor Activities in Natural Areas (non-consumptive activities) ($ millions)	Total Nature-related Expenditures (accommodation, transportation, food, equipment and other items) ($ millions)	Nature-related Expenditures Contribution to GDP ($ millions)	Estimated Net Economic Value of Nature-related Activities* ($ millions)	Employment Created from Nature-related Expenditures (jobs)
1981	118.3	172.3	128.1	42.7	4,411
1987	181.5	223.8	220.6	34.3	4,576
1991	76.7	173.0	180.0	22.0	4,002
1996	263.7	387.8	374.1	72.2	7,800

*Footnote: *Participants stated they would be willing to increase their expenditures by this amount before deciding to forego these activities.*
Source: Environment Canada, 1986, 1990, 1994, 2000.

According to two other surveys, the Canadian Travel Survey and the International Travel Survey (Tourism Saskatchewan, 2001), visitors participating in outdoor activities in Saskatchewan spent $221.5 million on outdoor-related expenditures in 1996. Expenditures have been steadily increasing from 1996-2000 (see Table 3.8). By 2000, $330.0 million was spent on outdoor-related expenditures within the province.

Table 3.8 Visitor Expenditures on Outdoor Activities* in Saskatchewan (regardless of purpose of trip)

Year	Total Visitor Expenditure ($ millions)
1996	221.5
1998	264.2
1999	293.1
2000	330.0

*Footnote: *Outdoor activities include fishing, hunting, camping, visiting parks, water sports, bird/wildlife viewing, walking/hiking and other active sports.*
Sources: Tourism Saskatchewan, 2001.

3.6.2 - Ecotourism and Provincial Parks

Ecotourism has become increasingly popular in the last decade, as seen in the increases in nature-related expenditures. In the late 1990s, an estimated 1.3 million travelers took part in ecotourism activities each year, spending approximately $142 million on ecotourism-related goods and services (Lozinsky, 1999). In Saskatchewan, $39.3 million was spent just on wildlife viewing in 1996 (Environment Canada, 2000). Total expenditures on tourism (including ecotourism) in the province have increased from $705 million in 1987 to $1,311 million in 2000 (Sawatzky, 2002). Accordingly, the increase in demand for ecotourism has been met by an increase in the number of outfitting operations throughout the province (Table 3.9). In 1987, there were 170 licensed outfitters in Saskatchewan, most of whom were northern fish outfitters. By 1995, the number of licensed outfitters in Saskatchewan had increased to about 625, and has remained at around that number to present. It was estimated in 2002 that outfitting would generate $117 million in revenue, directly employ 1,000 people, and attract up to 20,000 visitors who use the service of a licensed outfitter (Cherney, 2002).

Table 3.9 Licensed Outfitters in Saskatchewan

Year	Number of Licensed Outfitters in Saskatchewan
1987	170
1995	625
2001	609

Source: Cherney, 2002.

Use of provincial parks is another component of ecotourism activities. Visitations to provincial parks have slightly increased over the past 10 years, from 1,998,102 visitors in 1991 to 2,361,594 visitors in 2001 (SERM, 1995, 2001) (Table 3.10). Annually, provincial parks attract over $5 million in expenditures by out-of-province tourists and $18 million by in-province tourists. It is estimated that over $125 million in economic activity is generated directly by Saskatchewan's provincial parks, with most of the revenues remaining in rural areas (SERM, 2002).

Table 3.10 Saskatchewan Provincial Parks Statistics

Year	Estimated Total Visitation
1991	1,998,102
1996	2,408,230
2001	2,361,594

Sources: SERM, 1995, 1998, 2001.

3.6.3 - Sport Fishing and Hunting

An important component of nature-related expenditures is the economic activity generated from sport fishing and hunting in the province (Table 3.11). Expenditures directly related to sport fishing have been steadily increasing over the years. Anglers alone spent $108.2 million on activities directly attributable to sport fishing in 2000, compared to $41.8 million in 1980. Overall, anglers spent $243 million on goods, services and investments in Saskatchewan in 2000, indirectly and directly attributable to sport fishing (Saskatchewan Environment and Department of Fisheries and Oceans).

Unlike angling, the economic revenues from hunting show decline, as hunters spent $20.3 million less on activities directly attributable to hunting in 1996 ($33.7 million) than in 1981 ($54.0 million). The amount that hunters spent on all goods, services and investments made in Saskatchewan directly and indirectly attributable to hunting may or may not show the same percentage difference between these years (Environment Canada, 1986, 2000).

Table 3.11 Economic Revenues from Activities Directly Attributable to Hunting and Sport Fishing in Saskatchewan

Year	Hunting ($ millions)	Year	Fishing ($ millions)
1981	54.0	1980	41.8
1987	42.3	1985	70.7
1991	49.1	1990	86.7
1996	33.7	1995	95.4
2001		2000	1,082.0

Sources: Environment Canada, 1986, 1990, 1994, 2000; SPRR 1981; SPRC and Department of Fisheries and Oceans, 1986; SERM and Department of Fisheries and Oceans, 1991, 1996.
Data Source for 2000: Saskatchewan Environment and Department of Fisheries and Oceans.

3.7 - MANUFACTURING

Saskatchewan's manufacturing industry is a significant contributor to the economy. Since 1986, its contribution to the province's GDP has increased, from $971 million in 1986 to $1,314 million in 1996 (Saskatchewan Bureau of Statistics, 2001b). Employment in the manufacturing sector has increased by 41.9 per cent since 1987, from approximately 21,000 in 1987 to 29,800 employed in the manufacturing sector in 2001 (Saskatchewan Bureau of Statistics, 2002a) (Table 3.12). The largest components of the manufacturing sector in Canada, in terms of share of GDP, include transport equipment, food processing, chemical products, electrical products, printing and publishing, and fabricated metals.

Table 3.12 Manufacturing Statistics in Saskatchewan

Year	Contributions to GDP ($ millions)*	Employment (thousands)
1986	971	21.0 (1987)
1991	1,005	23.7
1996	1,314	28.4
2001		29.8

*Footnote: *Constant 1992 dollars.*
Sources: Saskatchewan Bureau of Statistics, 2001b; Saskatchewan Bureau of Statistics, 2002a.

Environmental Stresses, Condition and Management Response

4
AIR

CHAPTER OVERVIEW

Key activities or events affecting air quality: transportation, power generation, agriculture, oil and gas, forest fires, urban development, mining, pulp and paper. General impacts or effects can include: sulphur dioxide, nitrogen oxides, carbon dioxide, carbon monoxide, volatile organic compounds, hydrocarbons, airborne particulate matter, chlorofluorocarbons.

Selected indicators or measures of air quality: air pollution index, greenhouse gas emissions, acid deposition, ozone layer thickness.

Potential risks to ecosystem and human health: climate change, lake acidification, respiratory ailments, skin disorders.

Key management activities and programs: greenhouse gas emission reduction, technology-based innovation, energy conservation initiatives, acid deposition monitoring, Saskatchewan Agricultural Burning Awareness Program.

General Observations and Trends:
Due to the low density of the overall provincial population and moderate level of industrial activity, the air quality in Saskatchewan is generally good. However, there are a few regional exceptions.

A variety of human activities contribute to lower air quality in the province. Transportation and power generation are two major activities that emit a variety of air pollutants.

Greenhouse gas emissions have risen in Saskatchewan due to increasing economic activities. By 2020, it is projected that greenhouse gas emissions in the province will have increased by 45 per cent since 1990.

Saskatchewan does not have a general acid rain deposition problem. However, due to growing heavy oil development in Alberta, concern has been raised about acid rain depositions impacting fresh water lakes in the adjacent areas of northwestern Saskatchewan.

Urban air quality is currently measured in the cities of Saskatoon and Regina, and according to the National Air Pollution Index, air quality in both cities has been rated as good each year between 1996-2001.

4.1 - INTRODUCTION

The following chapter on air quality is organized to provide information on four general areas: key activities or events affecting air quality and the associated impacts; selected indicators and measures of air quality; potential risks to ecosystem and human health; and key management activities and programs.

Air quality is affected by airborne particulates and pollutants. Fuel emissions from industrial sites and transportation, stubble burning, blowing dust from wind erosion, smoke from forest fires and pollen from plants are all sources of airborne particulates.

Rain, snow and wind help maintain air quality, but the release of wastes from various sources can exceed the natural ability of the atmosphere to assimilate and disperse a wide range of air pollutants. The sources of air pollution can be local, regional or global in nature. Stubble burning, forest fires and power generation are examples of local activities that can impact air quality. On a global scale, volcanic eruptions can significantly affect the Earth's atmosphere.

The information presented is not intended to provide an exhaustive description of air quality and air-related issues, but rather to present key information that is currently available. Work is ongoing to improve environmental databases and assessment practices. However, this is a long-term process. This report is based on the best available information at the time of print.

Acid Rain & Smog

Acid rain results from sulphur dioxide and nitrogen oxides combining with moisture in the atmosphere to form acidic particles that eventually fall to the earth as precipitation. These airborne particles can be carried for days over hundreds of kilometres before precipitating. Acid rain can harm and even destroy aquatic vegetation, aquatic organisms and terrestrial vegetation. It can also corrode buildings and monuments, and acidify soil to the point where it is no longer fertile.

Smog is composed of a mixture of solid and liquid fog and smoke particles formed through the accumulation of carbon monoxide, ozone, hydrocarbons, volatile organic compounds, nitrogen oxides, sulphur oxide, water, particulates, and other chemical pollutants. It forms when some of these chemicals react in the presence of sunlight. Weather conditions are critical to smog formation, with high temperatures and long hours of sunlight enhancing the process. Smog interferes with photosynthesis in plants (the process where sunlight is converted into energy), reduces visibility and impairs human health.

4.2 - KEY ACTIVITIES OR EVENTS AFFECTING AIR QUALITY

A range of human activities and natural events affects air quality. The following discusses how some key activities and events impact Saskatchewan's air quality.

4.2.1 - Transportation

A significant number of air pollutants are released through the combustion of fuels in transportation: carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides, hydrocarbons and volatile organic compounds (VOCs). Transportation accounts for 70-90 per cent of carbon monoxide emissions in developed countries. At high enough concentrations, carbon monoxide causes respiratory problems in humans and inhibits photosynthesis in plants. Carbon dioxide is a greenhouse gas (GHG). Transportation accounts for 30 per cent of all carbon dioxide emissions. Transportation accounts for nearly half of the total emissions of nitrogen oxides, hydrocarbons and organic VOCs. Nitrogen oxides are serious GHGs and contribute to smog and acid rain (see sidebar). Hydrocarbons and VOCs are carcinogenic (cancer-causing) to some extent, contributors to smog, harmful to plant-life, and accumulative as they move up the food chain. Sulphur dioxide emissions, of which transportation accounts for about 5 per cent of all emissions, contribute to acid rain, cause and worsen respiratory and cardiovascular problems, and inhibit physiological activity in plants. Transportation accounts for one-quarter of all particulate emissions. Particulates are carcinogenic, worsen respiratory and cardiovascular problems, and also inhibit plant growth (Rodrigue, 2002).

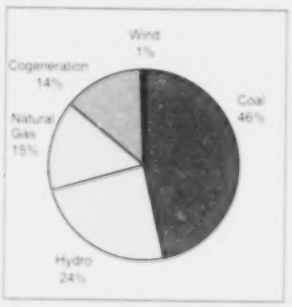
Chlorofluorocarbons (CFCs) are primarily released through vehicular air-conditioning systems that still use CFC freon, although this chemical's use has been reduced considerably throughout Saskatchewan and North America. CFCs contribute to the thinning of the protective ozone layer. The refrigerant of choice for automobiles is HFC-134a, which has no ozone-depleting potential, but is a GHG.

4.2.2 - Power Generation

In Saskatchewan, electricity is generated through a variety of sources, including hydro and wind, but most electrical energy is generated through the burning of fossil fuels, such as coal and natural gas (Figure 4.1). Over 70 per cent of the province's electrical needs are met through fossil fuels. Cogeneration has been included as a power generation source in Saskatchewan since 1999. It involves the simultaneous generation of electricity and useful heat or steam (usually through the burning of natural gas) for industrial purposes or to provide heat for a facility or community. Also, wind power has been recently added to the provincial power generation mix, including the SunBridge and Cypress wind power projects located in southwestern Saskatchewan.

The use of fossil fuels for the production of electricity is responsible for the emission of pollutants such as sulphur dioxide and nitrogen oxide emissions, which contribute to greenhouse gases (GHGs), acid rain and smog. Carbon dioxide, also released in large quantities, is the principal GHG contributing to global warming.

Figure 4.1 Generation of Electrical Energy in Saskatchewan by Type



Data Source: SaskPower

4.2.3 - Agriculture

As previously outlined, agriculture is carried out on over 26 million hectares in Saskatchewan, and there are a recorded 50,598 farms. The average farm size is 519 ha, and the average cultivated area on farms is 394 ha.

Agriculture contributes to air pollution through a number of activities. Tillage accelerates the breakdown of soil organic matter and releases carbon dioxide from the soil to the atmosphere. Fertilizer and manure management practices can also increase emissions of nitrous oxide, a potent greenhouse gas (GHG). The GHG methane is also released during the storage and field application of livestock manure. Dust arising from cultivation can cause human health concerns when the particulates become airborne and are small enough to penetrate the lungs. Smoke from the burning of crop residues can also cause health problems and contribute to the production of GHGs. Pesticides can be an air quality concern if crop protection products are applied during weather conditions that allow the pesticide droplets to drift onto adjoining areas. Pesticide products may also be carried on soil particles, so proper soil management is needed to prevent wind erosion. Gasoline and diesel fuel used in farm equipment also contribute to the province's GHG emissions. However, agricultural practices such as zero and minimum tillage have reduced the amount of fuel used in field operations. This practice also reduces the amount of carbon dioxide released from the land and results in soils becoming a net sink or storage reservoir for carbon, rather than being a source of GHG emissions.

4.2.4 - Oil and Gas

Air quality is often affected by the processing of natural gas and oil. Solution gas flaring involves burning natural gas that cannot be processed or sold. This flaring releases toxins including greenhouse gases and carcinogens (cancer-causing chemicals). Improper combustion of the gas contributes to increases in hazardous chemicals being released into the environment, including volatile organic compounds. In 2000, a total of 429,509,500 m^3 (at 101.325 kPa and 15°C) of natural gas was flared, vented or wasted, almost exclusively from oil well production sites in Saskatchewan. This represents 5.27 per cent of the natural gas that was produced in the province.

A number of other processes cause air quality to deteriorate. Glycol dehydrators, which remove water from natural gas, emit toxic chemicals such as benzene and other hydrocarbons that contribute to smog formation and may cause adverse health effects. Oil refineries release dioxins into the air, which then can precipitate into waterbodies and become concentrated in fish. The chemicals can also be inhaled by workers and people who live close to the refinery. Dioxins can cause cancer, reproductive effects and immune system dysfunction. Other health risks are created when hydrogen sulfide is removed from sour gas (natural gas with high hydrogen sulfide content).

4.2.5 - Forest Fires

Wildfires, particularly intense forest fires, release large quantities of airborne emissions, which can affect vegetation and human health. These emissions include particulate matter, in the form of smoke and ash, and other compounds, such as carbon monoxide and ozone. Forest fires are primarily a concern in northern Saskatchewan, but smoke can travel thousands of kilometres, depending on air currents, so that residents in the south are occasionally affected.

4.2.6 - Urban Development

Urban centres tend to be at higher risk from air pollution problems because of the sheer number of people living and working in relatively small areas. Smog and particulates are two such air pollution issues. Smog is generally more localized in its impact, particularly affecting large, industrial cities and surrounding areas.

Industries and vehicles emit particulate matter, which can reach high concentrations, particularly in urban areas. Airborne particulate matter (PM) can impact human health. Fine particulates that measure less than 2.5 microns (μ) in diameter ($PM_{2.5}$) have the ability to penetrate deeply into lungs. Airborne particles can eventually precipitate into waterbodies and onto vegetation, causing further contamination of land and water.

Air pollution is a significant problem for large, industrial cities that are confined by geographical barriers such as mountains. Saskatchewan's cities are relatively small and are situated on a level plain, so that smog buildup and other air pollution issues pose less of a threat.

4.2.7 - Mining

Throughout the mining process, greenhouse gases, particulates and other emissions result from the operation of vehicles, machinery, mines and mills. In the processing phase, smelters and blast furnaces are used to produce such metals as copper, lead, zinc, nickel, iron, steel and aluminum. Smelters, particularly those without sufficient safeguards, have the potential to pollute the air with heavy metals, sulphur dioxide and other pollutants. Although there are no smelters in Saskatchewan, these pollutants can travel long distances through the air. Sulphur dioxide is a contributor to acid rain, which can be detrimental to vegetation and aquatic life in lakes. The atmospheric deposition of toxins from various mining activities, particularly smelting, can harm vegetation for years into the future by contaminating the soil.

4.2.8 - Pulp and Paper

Much of the air emissions created by the forestry sector are emitted in the processing stage. Pulp mills emit sulphur oxides, nitrogen oxides and particulates. Sulphur and nitrogen oxides contribute to acid rain and smog, while particulates tend to worsen respiratory and cardiovascular problems and inhibit plant growth. Within Saskatchewan, there is a hardwood pulp mill located in Meadow Lake and a softwood pulp and paper mill located in Prince Albert.

Greenhouse Gases

Greenhouse Gases
In terms of potential to cause rapid climate change, Canadian greenouse gas (GHG) emissions are about 78 per cent carbon dioxide, 13 per cent methane and 8 per cent nitrous oxide, with other compounds making up the remainder. The buildup of GHGs in the earth's atmosphere is believed to be contributing to global climate change, including a significant rise in average temperatures globally and in Saskatchewan over the next century. See table for GHGs and their sources.

Types, Sources and Global Warming Potential of Greenhouse Gases

Greenhouse Gas	Chemical Symbol	Sources	GWP*
Controlled**			
Carbon Dioxide	Co_2	Occurs naturally. Also a by-product of burning fossil fuels and biomass, land use changes and various industrial processes	1
Methane	CH_4	Occurs naturally. Other sources are landfills, coal mines, natural gas systems and livestock	23
Nitrous Oxide	N_2O	Generated by burning fossil fuels, in the manufacture of fertilizer and cultivation of soils	296
Perfluorocarbons (PFCs)	Various compounds	Human-made chemicals. A by-product of aluminum smelting. Also used as a replacement for CFCs in manufacturing semiconductors	120 to 12,000
Hydrofluorocarbons (HFCs)	Various compounds	Human-made chemicals used largely in refrigeration and insulating foam	5,700 to 11,900
Sulphur Hexafluoride	SF_6	Used largely in heavy industry to insulate high voltage equipment and to assist in the manufacture of cable cooling systems	22,200
Uncontrolled**			
Water Vapor	H_2O (gas)	Naturally occurring. Rising global temperature may act to increase water vapour in the atmosphere	Not agreed upon
Ozone	O_3	Naturally occurring. Also created by reactions involving volatile organic compounds and nitrogen oxide gases resulting from motor vehicles and power plants.	Not agreed upon

Footnotes:

* *Greenhouse gases are generally referred to as CO_2-equivalent, using global warming potentials (GWPs). The GWPs are used to convert GHGs to a CO_2-equivalent basis so that the relative magnitudes of different GHGs can be readily compared, on a per unit mass of gas basis for a period of 100 years. For example, 1 kg of methane has a GWP 21 times greater than 1 kg of Co_2 over a 100-year period.*

** *Controlled GHGs will be controlled under the Kyoto Protocol and uncontrolled GHGs will not be controlled under the Kyoto Protocol.*

Source: Climate Change Saskatchewan, n.d.

4.3 - SELECTED INDICATORS OR MEASURES OF AIR QUALITY

Although there is a range of human activities and natural events that impact air quality, it is not possible to monitor all of these impacts. Rather, certain indicators or measures are selected to be monitored or tracked to assess how air quality in the province is changing. The following section provides information on these indicators and measures.

4.3.1 - Air Pollution Index

Saskatchewan's Air Pollution Index (API) uses air quality objectives or standards as a numerical basis to measure air quality. It is based on the measured outdoor concentrations of the major pollutants (suspended particulate matter, ground-level ozone, carbon monoxide, sulphur dioxide and nitrogen dioxide). The API is also referenced to the current state of evidence on the adverse health effects of air pollution (refer to air pollution index sidebar).

The API is reported on a scale of 0-100, with 100 being the best. The lower the number, the more polluted the air, and the higher the risk to human health. The descriptive terms for the specific numerical values are listed in Table 4.1.

Table 4.1 Human Health Descriptors for the Air Pollution Index

Descriptor	Numerical Values	Effects
Excellent	100 - 85	No known risk to human health
Good	84 - 70	Negligible risk to human health
Fair	69 - 55	Potentially unhealthy for some sensitive groups of individuals (children, seniors, those with heart and lung disease are at greater risk)
Marginal	54 - 35	Air pollution is associated with harmful effects ranging from minor irritations of the throat, to worsening of asthma and other lung conditions.
Poor	34 - 0	Possibility of severe conditions including increased mortality

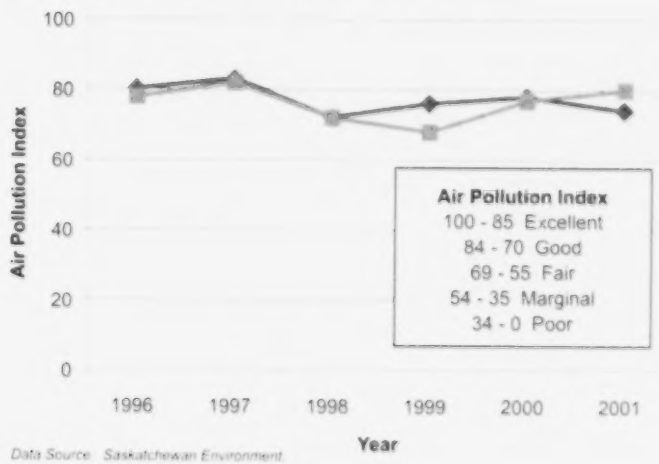
Source: Saskatchewan Environment

The data used for the API is collected from two continuous monitoring stations - one in Regina and one in Saskatoon. Over the next few years monitoring stations in Swift Current and La Ronge will be brought online. For more information on the API and its development, see the air pollution sidebar.

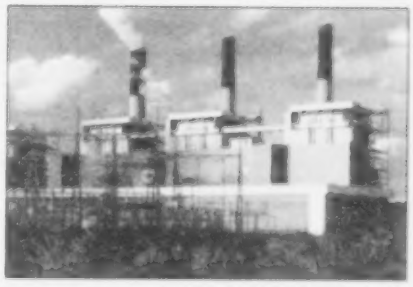
Air pollution levels over the previous six years in Regina and Saskatoon were fairly consistent and fell within the "good" range, with the exception of Saskatoon for 1999, which was considered "fair" by a marginal fraction. On an annual cycle, poorer air quality usually occurs during the summer and fall seasons. Under windy and hot conditions, forest fire smoke (and in the fall, stubble burning smoke) and particulates are typically transported over large areas of the province, contributing to a decline in air quality and, hence, an increase in overall risk to human health. There have been occasional days in both Regina and Saskatoon during the summer and fall in which particulate matter, in the 2.5 μ (micron) range, would present a potential health risk to those individuals with lung ailments.

In Saskatchewan, particulate matter tends to be the driver of the API. Occurrences of elevated levels of ground-level ozone or nitrogen dioxide are rare, and occurrences of elevated levels of carbon monoxide and sulphur dioxide are very rare. The index is graphically represented in Figure 4.2 for both Regina and Saskatoon over a five-year period.

Figure 4.2 Air Pollution Index for Regina and Saskatoon



Data Source: Saskatchewan Environment



Air Pollution Index

The Federal-Provincial Committee on Air Pollution published a guideline for an annual air quality index (Index on the Quality of Urban Air [IQUA]) in August 1980. The index uses air quality objectives or standards as the numerical basis for the index. It transforms the measured concentrations of certain air pollutants into a single number and descriptive term that represents both the measured and the publicly perceived quality of the ambient air for a given time period and location. It is based on the measured outdoor concentrations of the major pollutants.

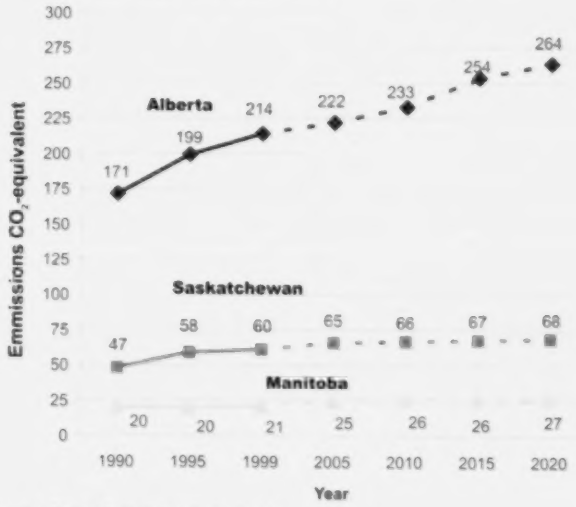
Although a federal-provincial committee developed the IQUA, Saskatchewan Environment has customized the index to meet our specific needs. Rather than keeping the IQUA strictly as an air quality measure, Saskatchewan Environment has modified it to be an overall pollution index tied to the likelihood of experiencing harmful health effects. In this way, the Air Pollution Index provides information to the public enabling them to take appropriate actions to protect themselves from the adverse effects of air pollution.

Certain assumptions and value judgments are inherent in the index, perhaps the most important being the use of 98th percentile concentration. This is recommended by the World Health Organization and means, for example, that an annual index number of 68 ("fair") as reported for Saskatoon during 1999 would mean the pollution levels have been better than or equal to 68 for 98 per cent of the time during the year. It does not mean that the average air quality was 68. The remaining (or worst) 2 per cent of the percentile usually reflects anomalies such as weather, pollution, possible errors in the data, etc. With this in mind, caution is advised in using the index to compare the two major cities. These index results are better utilized in comparing long-term trends at each individual station.

4.3.2 - Greenhouse Gas Emissions

Saskatchewan greenhouse gas (GHG) emissions have risen 32 per cent between 1990 and 2000, and are projected to rise another 13 per cent by 2020. Figure 4.3 compares past GHG emissions and future projections for Alberta, Saskatchewan and Manitoba. In Saskatchewan, it is projected that, by 2020, GHG emissions will have increased 45 per cent since 1990. This will be lower than in Alberta (54 per cent), but higher than in Manitoba (35 per cent).

Figure 4.3 Comparative Greenhouse Gas Emissions (actual and projected) for Alberta, Saskatchewan and Manitoba



Source: Climate Change Saskatchewan, n.d.

Saskatchewan's extreme climate, increased demand for electricity, use of coal and natural gas for power, energy-intensive industries and widely spaced population contribute to high levels of GHG emissions. Table 4.3 presents Saskatchewan's GHG emissions by sector from 1991-2000. Over this time period, certain industries have had GHG emissions increase by a greater magnitude than others. The industrial processes sector has significantly increased its GHG emissions from 680 kilotonnes (kt) in 1991 to 2,000 kt in 2000. Fossil fuel industries alone have increased from 1,630 kt in 1991 to 4,400 kt in 2000. GHG oil and gas fugitive emissions, those that have escaped from a product or process in this sector, have increased from 6,300 to 11,000 kt. The commercial/institutional sector's emissions have also increased from 1,010 to 1,710 kt. The agriculture sector's GHG emissions returned to 1991 levels (11,000 kt) by 2000. The transportation sector accounted for 11,200 kt of GHG emissions in 2000, a slight increase from 1991 emission levels.

Table 4.2 Greenhouse Gas Emissions from Some Selected Economic Sectors in Saskatchewan

Sectors	1991*	1996*	2000*
Fossil Fuel Industries	1,630	3,420	4,400
Electricity and Heat Generation	10,500	14,200	14,500
Mining	978	1,320	2,140
Manufacturing	1,340	1,570	893
Transportation	9,620	11,800	11,200
Residential	2,150	2,450	1,980
Commercial/Institutional	1,010	1,420	1,710
Oil and Gas (fugitive)**	6,300	9,600	11,000
Industrial processes	680	1,700	2,000
Agriculture	11,000	12,000	11,000
Waste Disposal	520	580	610
Total All Sources***	46,100	60,100	61,800

Footnotes:
** All numbers in kilotonnes (kt) of CO_2 equivalent for all GHGs.*
*** Emissions that escape from a product or process.*
**** Total is greater because it includes emissions from more than the selected sectors.*
Source: Olsen et al., 2002.

4.3.3 - Acid Deposition

It is estimated that 1,471 kt of sulphur dioxide and 169 kt of nitrogen oxides were emitted in Saskatchewan in 2000 (Environment Canada, 2000), through such activities as production and refining of oil and gas, and transportation. Because of prevailing wind conditions, the vast majority of out-of-province sources of acidifying emissions tend to be from Alberta. Estimates suggest that as much as 70 per cent of the sulphur and nitrogen emitted in Alberta is deposited in Saskatchewan (McDonald et al., 1996). This is of particular concern since Alberta's emissions of acidic and acid-forming substances are at least six times the amount of those produced in Saskatchewan (Environment Canada, 2000). There are also indications that these emissions will substantially increase over the next couple of decades unless adequate measures are taken at source to reduce emissions. Table 4.4 shows sulphur dioxide and nitrogen oxide emissions for Saskatchewan, Manitoba, Alberta and Canada for 1995.

Table 4.3 Sulphur Dioxide (SO_2) and Nitrogen Oxide (NO_x) Emissions for the Prairie Provinces and Canada in 1995

Jurisdictions	SO_2 (tonnes)	No_x (tonnes)
Alberta	1,216,125	1,290,315
Saskatchewan	261,999	383,656
Manitoba	730,871	182,742
Canada	5,306,573	4,711,364

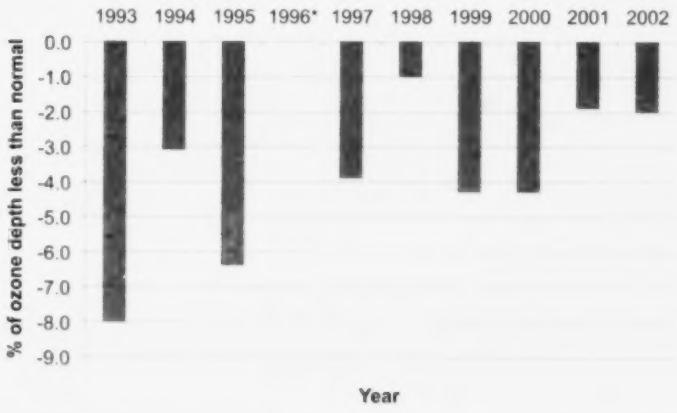
Source: Environment Canada, 1995.

In managing the acidification of waterbodies in Saskatchewan, the goal is to keep acidification to less than 40 per cent of the critical load. The critical load is the acid deposition level above which irreversible change occurs in the function of an ecosystem. The target load has been defined as 40 per cent of the critical load a "red flag" level. An analysis of 125 lakes and 50 ponds in northern Saskatchewan indicates no areas are currently exceeding their target loads. However, based on long-term projections of acid gas emissions and lake data on the acid neutralization capacity, within the next 25-50 years, there is a risk of exceeding the target load in about 30 per cent of the lakes and the critical load, in about 10 per cent of the lakes. These lakes are located directly east of the oil sands projects in Alberta and extend across the Alberta-Saskatchewan border towards the north central portion of Saskatchewan.

4.3.4 - Ozone Layer Thickness

The global use of ozone-depleting substances is causing a thinning of the protective ozone layer around the Earth. See Figure 4.4 for average ozone layer thickness values in Canada. From this graph it is apparent that the ozone layer is thinner than normal over Canada. It does appear to be thicker now than it was in 1993, but more years of data are needed to determine a trend.

Figure 4.4 National Annual Averages of Ozone Layer Stations for Canada, 1993-2002



*Footnotes: *Data not available for 1996.*
The above graph represents the annual average departure between the observed ozone values for 10 stations across the country and the pre-1980 climatology. Values were determined using Direct Sun observations.
Source: Environment Canada, n.d.

4.4 - POTENTIAL RISKS TO ECOSYSTEM AND HUMAN HEALTH

Air pollution can extend over large areas, and therefore its affects are often far-reaching. Entire ecosystems may change due to altered atmospheric conditions. Human health may also suffer. The following section describes some of the major impacts of air pollution on ecosystems and human health.

4.4.1 - Climate Change

One of the most important global environmental challenges is the issue of climate change and greenhouse gas (GHG) emissions. There is a growing concern in the scientific community that increased levels of GHGs in the atmosphere are causing temperature increases worldwide. Although there is disagreement among scientists as to what the exact effects of climate change may be, it is certain that there will be changes. Rapid and long-lasting extremes in climate may overwhelm an ecosystem's ability to adapt. Ecosystem processes and composition may change so that a different ecosystem develops. Forests may shrink to be replaced by scrub and grassland; grassland may shrink to be replaced by desert. There may be warmer winters and more extreme climatic events, such as floods, storms and droughts.

Climate change and warmer temperatures may also augment the impact of pollution. Warmer conditions can increase the amount of smog in urban areas. Droughts can reduce the supply of safe drinking water and increase the concentration of contaminants. Floods wash sewage and disease-causing organisms into water supplies, potentially causing epidemics and plagues. More frequent and severe weather events, including extreme temperatures, could lead to injury, death or displacement.

Ecosystem disruption as a result of climate change may foster the invasion and growth of "pest" populations and enhance the spread of diseases. It may also extend the range of some organisms such as mosquitoes, rodents and ticks, which could increase the chances of new viruses and other problem organisms emerging.

4.4.2 - Lake Acidification

Acid deposition from acid rain can result in lake water becoming too acidic for certain species of life, including fish. Over time, a lake can essentially become dead, even though it looks clean and clear. In particular, this can happen in the north on the Shield, where there is little buffering capacity from the acidic soils and rock.

Acid rain erodes buildings and affects plant life. It is unlikely that humans are immune to its effects. Acidification can also contribute to high levels of heavy metals in drinking water. Metals, both in soils and in water distribution pipes, can be mobilized by acidified groundwater.

4.4.3 - Respiratory Ailments

Except for massive exposures, it is very difficult to track the effects of low-level exposures to air pollutants in humans. It is possible, however, to make causal links between airborne particulates and respiratory difficulties. Airborne particulates, sulphur dioxide, nitrogen oxides and ozone all aggravate or cause respiratory distress. Children, the elderly and people with asthma, cardiovascular disease or chronic lung disease (such as bronchitis or emphysema) are most susceptible to adverse health effects associated with exposure to air pollutants. There is no long-term data to establish a direct link between air pollution and asthma in Saskatchewan. Stubble burning and forest fires, though, do create problems for people with respiratory ailments.

4.4.4 - Skin Disorders

The thinning of the ozone layer is leading to a higher incidence of skin cancers. Over the last 15 years, the incidence of skin cancer in Canada has doubled (Health Canada, 1997) however current data for Saskatchewan does not indicate the same increase. There is no data on protective measures taken, number of sunny days or duration of exposure to sunlight, which also affects the incidence of skin cancer. It is known that prolonged exposure to UV rays can cause premature aging, wrinkling of skin, depression of the immune system, allergic reactions and eye problems, such as inflammations, cornea damage and cataracts.

4.5 - KEY MANAGEMENT ACTIVITIES AND PROGRAMS

In response to continual changes in air quality, environmental managers have enforced stringent regulations and implemented a variety of activities and programs to protect and restore Saskatchewan's air quality. Some of these activities and programs are outlined in the following section. This section does not cover all programs and activities related to air quality, but rather touches on some of the key initiatives currently underway.

4.5.1 - Greenhouse Gas Emission Reduction

The 1997 Kyoto Protocol is the first international agreement calling for binding limits on anthropogenic (human-causing) greenhouse gas emissions. The intent of the Kyoto Protocol is to reduce the GHG emissions of developed countries to an average of 5.2 per cent below 1990 levels. Canada agreed to a 6 per cent reduction below 1990 levels by the first commitment period (2008-2012). The Canadian parliament formally committed Canada to the Kyoto Protocol in December of 2002.

Due to economic and population growth, Canada's GHG emission levels have risen significantly. In 1990, Canada emitted approximately 600 megatonnes (Mt) of GHG emissions. Given the current rate of emissions growth, it is expected that by 2010, Canada's emissions will have grown to 810 Mt, exceeding the Kyoto target by 240 Mt. In percentage terms it means that Canada's annual GHG emissions must be reduced by 30 per cent to meet the Kyoto Protocol.

SaskPower's solar project at the Saskatchewan Science Centre and a flare gas project and a co-generation pilot at the Regina General Hospital are examples of innovative emission reduction initiatives. Distributed generation projects typically include installation and operation of small electric generators that use the waste found at a site of the power source (e.g., solution gas from oil wells, waste from intensive livestock operations and wood residues). SaskPower is also actively involved with other organizations that will help develop policies, reduce emissions and research offset opportunities for the future. These organizations include the Canadian Electricity Association (CEA), the Greenhouse Gas Emission Reduction Trading (GERT) Pilot and the Greenhouse Emissions Management Consortium (GEMCo).

SaskPower is also supporting research on various ways of physically mitigating the emission of GHG from its operations. The collaborative research initiatives with which SaskPower is currently involved are aimed at flue gas capture of carbon dioxide and the development of clean coal technology.

At Weyburn, Saskatchewan, a project to reduce GHG emissions is being undertaken under the auspices of the International Energy Agency (IEA) and directed by the Petroleum Technology Research Centre. The IEA Weyburn Carbon Dioxide (CO_2) Storage and Monitoring Project is investigating, with EnCana Corporation, storage of carbon dioxide in hydrocarbon reservoirs in association with a large-scale enhanced oil recovery (EOR) scheme. This project is international in scope. The Weyburn project is designed to verify permanent geological storage of carbon dioxide and to develop international protocols. The transfer of knowledge to other storage projects is an important aspect of the study. It is estimated that eventually up to 19 million tonnes of anthropogenic (human-caused) carbon dioxide will be stored in the subsurface, equivalent to the emissions produced by three million cars for one year.

Carbon sinks are areas where the rate of carbon uptake by living organisms is greater than the rate of carbon release in the form of carbon dioxide or other GHGs. Sinks can be forests, large waterbodies like the oceans, or soils that are high in organic matter.

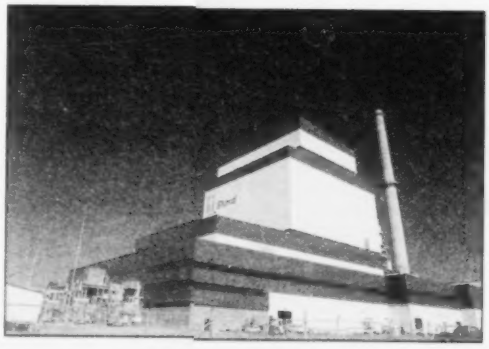
Through a collaborative project with Saskatchewan Environment, SaskPower has been able to secure forest management carbon sinks totalling 22 million tonnes of carbon dioxide equivalent. The project will offset GHG emissions in Saskatchewan by establishing the equivalent of more than 500,000 ha of forest carbon reserves - existing forests that will be left unharvested - and result in the planting of approximately five million seedlings in northern forests.

In the agricultural sector, there is an opportunity to use land to sequester carbon. Traditional dry land farming, using summerfallow and extensive cultivation, tended to release GHGs faster than they were sequestered. New farming techniques that reduce tillage and summerfallow, as well as use more permanent crops, are believed to sequester more carbon than is released as GHGs.

Increasing forages and permanent cover appear to provide better carbon sequestering capabilities than other tillage options. However, it is believed that the increased numbers of livestock (they produce high amounts of GHGs) associated with more pasture and forage would offset the gains in carbon sequestration from converting to permanent grasses and other forages. It should be noted that the concept of carbon sequestering in living organisms is a temporary measure to be utilized until GHG emissions can be reduced significantly on a global basis.

For more information on GHGs and climate change, visit Climate Change Saskatchewan at: www.climatechangesask.ca and Saskpower at www.saskpower.com/environment/rpp/climate01.pdf

4.5.2 - Technology-based Innovation



Our ability to use, adapt and create new technology is key to furthering energy conservation and reducing greenhouse gases (GHGs). SaskPower has been implementing new technologies that minimize the impacts of power generation on air quality. The Shand Power Station located near Estevan, for example, is deemed to be the most environmentally advanced, coal-fired generating station in Canada. The 300 megawatt (MW) plant has developed a number of strategies to achieve this standing. The plant burns low-sulphur coal that emits less sulphur dioxide, a major contributor to acid rain, than many other types of coal. The plant implements systems that use powdered limestone and water to remove sulphur dioxide emissions and a finely tuned burner temperature and air quantity to reduce nitrogen oxide emissions. The Shand station also uses technology that traps over 99 per cent of the ash from the burning of the coal before it leaves the power station's stack (SaskPower, 2002).

In response to the environmental and health effects of burning coal for the generation of electricity, SaskPower has implemented technological solutions to reduce or eliminate these effects. Coal-fired power stations are using the LIFAC (Lime Injection into the Furnace and Activation with Unreacted Calcium) system to reduce sulphur dioxide emissions and low-nitrogen oxide burners to reduce emissions that contribute to acid rain. Since 1998, SaskPower has been retrofitting units at Boundary Dam Power Station with electrostatic precipitators (ESPs) that are dramatically reducing the particulate emissions released to the atmosphere. This five-year project to update the technology at the utility's oldest and largest coal-fired station is the result of a partnership formed with Saskatchewan Environment. The precipitators are designed to a standard of 42.9 nanograms per joule (ng/J). Since the ESPs have been in operation at Boundary Dam, particulate emission levels have decreased by approximately 40 per cent.

Cogeneration offers economic and environmental advantages, including reduced GHGs. It uses a single fuel source, usually natural gas, to produce electricity and steam. In traditional power stations, heat from exhaust gases is lost to the atmosphere, but in cogeneration facilities, the heat is captured and used for other industrial purposes. Examples of cogeneration facilities in Saskatchewan include the Meridian Cogeneration Project at the Husky Oil Upgrader near Lloydminster, which has been in operation since 2000, and the Cory Cogeneration Station, which is currently under construction at the Potash Corporation of Saskatchewan (PCS) Cory mine site near Saskatoon.

4.5.3 - Energy Conservation Initiatives

Much effort has been focused in the area of energy conservation over the past few years. The establishment of the Office of Energy Conservation was announced in September 2002. The Office of Energy Conservation will be located in the Regina facilities of the Saskatchewan Research Council. The office is funded by SaskPower, SaskEnergy and Saskatchewan Industry and Resources. The office will undertake a number of energy conservation initiatives to reduce energy costs for Saskatchewan residents, businesses and farmers. The office will maintain a toll-free energy conservation hotline to provide information on energy conservation and alternative energy.

There is clear commitment to explore energy alternatives with the development of new wind power projects and ethanol production. With the support of the Government of Canada, Government of Saskatchewan and SaskPower, two wind power projects were developed for the Gull Lake area of southwest Saskatchewan. The 11 MW SunBridge Wind Power Project is a partnership formed by Suncor Energy Inc. and EnBridge Inc. to build, own and operate the wind facility. SaskPower is purchasing the green power generated for distribution to Saskatchewan customers. SaskPower has added a second facility, the Cypress Wind Power Project, a 5.9 MW project that was also built near Gull Lake. Saskatchewan has also established legislative authority to mandate the use of ethanol in gasoline, as productive capacity is established.

4.5.4 - Acid Deposition Monitoring

Monitoring of deposition is required to determine the amount of acid being loaded on terrestrial and aquatic systems. Wet deposition is relatively easy to monitor, involving the collection of precipitation and analysis of acidic deposition. Dry deposition is much more difficult and less precise to measure than wet deposition.

Canadian Air Precipitation Monitoring Network (CAPMoN) sites, operated by Environment Canada, are intended to provide data for the determination of spatial patterns and temporal trends in atmospheric pollutants related to acid rain. Wet deposition is collected, and both precipitation and air chemistry are measured. The CAPMoN site at Cree Lake, Saskatchewan, was decommissioned in 1994. Currently, the closest CAPMoN site to Saskatchewan is in Esther, Alberta (east of Calgary), but in the future it will be relocated to Bratt's Lake, Saskatchewan (just south of Regina).

4.5.5 - Saskatchewan Agricultural Burning Awareness Program

In response to public concerns, the provincial government established an inter-agency committee in 1999 to initiate the burning awareness program. Pilot projects were established in the Regina and Yorkton areas before expanding to the entire province. Saskatchewan's Agricultural Burning Awareness Program is intended to increase public and producer awareness of the environmental, health and safety impacts of crop residue burning. Burning of crop residues (straw and stubble) damages soil health, reduces crop nutrients and leaves soils vulnerable to erosion. Crop residues (straw and chaff) can also be a valuable source of feed and bedding for livestock.

The program involves a variety of extension activities including print and electronic media. A daily ventilation index forecast is provided on the program website at www.agr.gov.sk.ca/cropResidue/default.htm along with recommendations for beneficial management practices for handling surplus crop residues. With lower rainfall levels over the past few years, concerns about stubble fires escaping have increased.

5 LAND AND SOILS

CHAPTER OVERVIEW

Key activities or events affecting the quality of land and soils: agriculture, forestry, urban and municipal development, transportation and roads, mining, oil and gas development, sand and gravel extraction. The general impact of activities include: soil salinity, loss of organic matter, residual fertilizers and pesticides in soil, toxic compounds from landfills, abandoned contaminated sites, accidental soil contamination.

Selected indicators or measures of land and soil quality: use of improved land management practices, use of fertilizers and pesticides, waste reduction, contaminated sites cleaned up, cleanup of accidental spills.

Potential risks to ecosystem and human health: desertification of land, human exposure to pesticides and herbicides, bio-accumulation of toxic substances.

Key management activities and programs: soil management practices, organic farming, integrated pest management programs, new forestry harvesting practices, agroforestry, regional solid waste management, waste recycling programs, environmental monitoring for oil and gas activities, contaminated site cleanup.

General Observations and Trends:
Soils in the prairie provinces are considered to be, for the most part, in good condition. However, they are subject to stresses, particularly wind erosion and salinization.

Policies of government and farming practices in the past have often resulted in the degradation of the land and a general loss of native prairie grasslands. Changing farming practices in recent years is reducing soil erosion by wind and water, loss of organic matter and soil salinization.

The use of commercial fertilizer has fluctuated between 1996-2001, but the use of herbicides has increased for crop production in the province. Insect infestations are cyclical, which affects the use of insecticides in any given year.

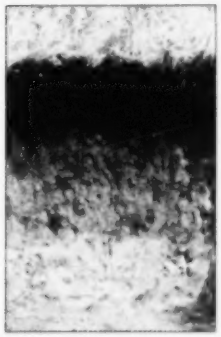
Saskatchewan farmers are beginning to develop integrated pest management practices to suppress pests more effectively and in an environmentally sound manner.

Forest harvesting practices are improving, and forest companies are required to develop sustainable forest harvesting plans that are intended to better manage environmental impacts.

Of the six highly contaminated sites identified in the province, four sites have been cleaned up between 2000-0. with the additional two being planned for clean up by 2003-04.

Since 1992, the province has instituted programs to encourage municipal regional solid waste management and waste recycling programs. These programs have resulted in a decrease in the number of landfills, a decrease in the amount of waste per capita and a significant increase in the recycling of beverage containers, paper, used oil, oil filters, scrap tires, batteries, glass and some metals.

5.1 - INTRODUCTION



The following chapter on land and soils is organized to provide general information on activities or events affecting land and soil quality, their impacts, the general condition or quality of land and soils, potential risks to ecosystem and human health and descriptions of activities underway to protect, manage or restore soil quality.

The following information is not intended to provide an exhaustive description of land and soil quality but rather presents key information that is currently available. Work by government is ongoing to improve environmental databases and assessment practices; however, this is a long-term process. This report is based on the best available information at the time of print.

5.2 - GENERAL DESCRIPTION

Saskatchewan has approximately 570,000 km^2 or 52 million hectares of land area. Natural landscapes form an important component of various ecosystems in the province. Land supports all terrestrial fauna and flora, and the production of food, fibre, wood and other products essential for the support of life in general and the economy in particular.

The quality of land and soils is affected by a range of human activities. The southern half of the province's landmass, the Boreal Plain and the Prairie ecozones, supports the majority of human activity and settlements. Agriculture, forestry, urban centres and an intensive network of roads and highways are the four major land uses impacting the physical and natural environment in this part of the province.

The northern half of the province, the Taiga and Boreal Shield ecozones, is very sparsely populated by humans. Forestry, outfitting, traditional hunting and fishing, and mining are the main land uses. Most of the northern land area of the province is still relatively undisturbed.

5.3 - KEY ACTIVITIES OR EVENTS AFFECTING LAND AND SOIL QUALITY

5.3.1 - Agriculture

In 2001, there were 26.3 million hectares of agricultural lands in Saskatchewan. Of this, it is estimated that 59 per cent is in cropland, 12 per cent in summerfallow, 5 per cent in tame or seeded pasture and 24 per cent is natural land for pasture. Agriculture is a significant land use in the province and, as such, has altered a large portion of the province.

Table 5.1 shows Saskatchewan trends in agricultural land use between 1971 and 2001. Land use trends over the past decade show a 14 per cent increase in hectares of land in crops since 1991, a 45 per cent decrease in hectares of summerfallow since 1991 and a 30 per cent increase in area seeded to perennial forages. Over the 20-year period from 1981 to 2001, the area in summerfallow has decreased by over 3.5 million hectares. Areas that used to be in summerfallow are now planted in crops or forage (continuous cropping).

Table 5.1 Trends in Agricultural Use of Land in Saskatchewan

Year	Land in Crops (ha)	Summerfallow (ha)	Tame or Seeded Pasture (ha)	Natural Land for Pasture and Other Undeveloped Land* (ha)
1971	11,064,153	6,701,761	792,480	7,770,123
1976	10,589,663	7,176,761	900,812	7,766,333
1981	11,741,282	6,704,703	975,399	6,526,637
1986	13,326,285	5,658,452	878,757	6,736,807
1991	13,459,394	5,713,034	1,075,693	6,618,323
1996	14,399,163	4,431,608	1,233,350	6,505,886
2001	15,376,476	3,131,752	1,405,785	6,352,567

*Footnote: *Includes natural pasture, wetlands, woodlands, building sites.*
Source: Statistics Canada, 2001a.

These changing farming practices help to increase the amount of organic matter and moisture in the soil and significantly reduce erosion and, therefore, help to reduce the impact of agricultural activities on the land. In addition, moving fragile lands from annual cropping to a permanent cover of forages and/or trees provides benefits to water quality by reducing sediment and nutrient flow into aquatic systems. This can also improve wildlife habitat and may help to alleviate the effects of climate change by holding more carbon in the soil. However, the increased area of cropland also results in the use of larger amounts of fertilizers, pesticides and other inputs.

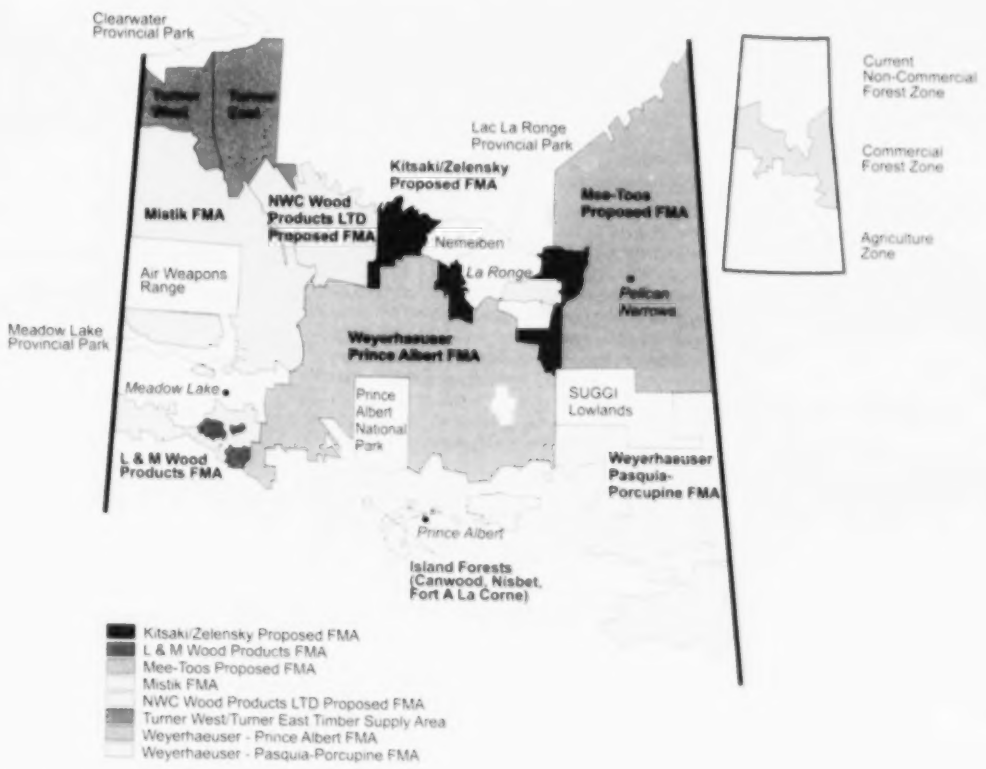
Nitrogen and phosphorus are the most common nutrients added as fertilizer. Most Saskatchewan soils have adequate levels of potassium, but potassium fertilizer may be needed in sandy-textured and gray soils. Soil sulphur levels may be deficient for crops such as canola, alfalfa and mustard. Soil testing is encouraged to determine the amounts of fertilizer nutrients required by each crop on a field-by-field basis.

Saskatchewan's extreme and variable climate is not highly conducive to the survival of most pests and naturally limits many pest populations. Consequently, Saskatchewan producers use a low level of pesticides on a per hectare basis relative to agricultural producers in other areas of the world. However, some pests are well adapted to our environment, and the practice of monoculture cropping (a reduced number of species planted over a large area) favors the development of host-specific pests. In general, herbicides represent 85-90 per cent of pesticides used in Saskatchewan. Fungicide use has been increasing over the past decade due to continuous cropping and an increase in specialized crops. Insect infestations are usually cyclical and have a dramatic impact on the volume of insecticides applied in any given year.

5.3.2 - Forestry

Forestry affects large tracts of land within the province. On average, over 24,000 ha of provincial Crown forestland are harvested each year. Most of the forest harvested comes from the Boreal Plain Ecozone, north of the prairies and south of the Canadian Shield, and 97 per cent of the commercial forest is provincial Crown land. In Saskatchewan, there are 12.2 million hectares of commercial forest which are managed through various agreements with industry (Council of Saskatchewan Forest Industries, 2001). Existing Forest Management Agreement areas for the province are illustrated in Figure 5.1.

Figure 5.1 Forest Management Agreement Areas in Saskatchewan's Commercial Forest (2001)



Data Source: Saskatchewan Environment

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Most of Saskatchewan's forest that has been harvested has been clear-cut. Clear-cutting modifies the forested ecosystem significantly. It changes from a site with tall trees providing a shaded environment to one that is open to the sun and wind. The site changes from having a moisture regime where water is held on site until it is taken up and transpired by the trees, to one that holds little water before it runs off. Compared to a wildfire, harvesting removes from the site most of the carbon and other chemicals and minerals contained in the wood. A burn deposits ash on the forest floor and leaves much of the larger timber standing to decay on site.

During the harvesting process, the land faces many possible immediate impacts, including soil compaction caused by heavy machinery, soil erosion due to the loss of vegetation and the loss of habitat for wild species only able to survive in mature forests. Soil fertility is reduced as well as the moisture-retaining capacity of the soil, thereby hindering the regeneration of new forest growth. In Saskatchewan, roads and trails needed to access and transport forest products from the forest to the mills may cause more serious,long-term problems than most of the actual forest cutting. Habitat fragmentation, dust and alteration of drainage are some of the more significant issues. A system of road closures and retirements are now included in many forest management plans to address some of the problem of roads in the forest. In addition, harvesting practices are beginning to change to help reduce impacts.

5.3.3 - Urban and Municipal Development

Saskatchewan is sparsely populated compared to other regions of the world. In 1997, using the total amount of land in the province, Saskatchewan had a population density of 1.8 persons per square kilometre, compared to 3.0 in Canada and 239.4 in the United Kingdom. Less than 0.3 per cent of the landmass is used for urban type development in 14 cities, 143 towns and 343 villages. The cities occupy a total area of 540 km^2 (54,000 ha), or 0.1 per cent of the province, excluding land covered by water. Regina covers 110.8 km^2 (11,080 ha) of land, and Saskatoon covers an area roughly equivalent (Fung, 1999).

The population within large urban centres in Saskatchewan is increasing, while the population in rural areas is decreasing. Between 1991 and 1996, Regina and Saskatoon were the only cities that had any significant population increases, 1.6 per cent and 3.0 per cent with land conversions of 5.4 per cent and 7.8 per cent, respectively. Between 1996 and 2001, both rates of population increase and land conversion decreased considerably. Regina's population increased by 0.7 per cent and Saskatoon's, by 4.1 per cent, with land increases of 267 ha and 143 ha, respectively (Statistics Canada, 2001b). Most of the population shifts in the province have been to areas surrounding urban centres.

Urban centres transform natural ecosystems into paved streets, human-made parks, parking lots, homes, factories and buildings. Cities absorb more heat than natural vegetation and promote greater runoff from precipitation, which can increase the risk of flooding. Settlement creates and concentrates waste in a local area and requires landfills and sewage treatment plants to dispose of this waste.

5.3.4 - Transportation and Roads

Although transportation benefits society by facilitating the movement of goods and people, it also has direct and indirect impacts on the environment.

Direct impacts include land use for transportation infrastructure such as roads, railways and airports. Once these facilities are in place, they need to be maintained, and these activities in turn affect the environment. A case in point is the use of road salt in winter and subsequent runoff due to the melting of snow and spring runoff.

The indirect impacts of transportation arise from subsequent use of the facilities. Vehicular traffic involves the consumption of fuel and emission of exhaust gases. Vehicles also leak lubricants, oil and heavy metals that can be carried onto soils and into waterways. Oil by-products, such as oil filters, contain small quantities of toxic substances, such as trace metals, gasoline and polychlorinated biphenyls (PCBs) as well. If these by-products are not properly disposed of or recycled, these contaminants can enter the soil and slowly accumulate within food chains. Other impacts include accidental spills from carriers of dangerous goods, road kills of wildlife and noise pollution from busy highways and thoroughfares.

Saskatchewan has Canada's largest road network, with approximately 26,000 km of provincial roads and highways, monitored by Saskatchewan Highways and Transportation. In addition, Saskatchewan rural municipalities oversee their own 160,000 km of roads that are mainly gravel. Since 1999, apart from the twinning initiative (107 km) of the Yellowhead and TransCanada highways and the construction of the Athabasca Seasonal Road (181 km), the road network has changed little. In fiscal year 2002-2003 Saskatchewan Highways and Transportation will twin an additional 27 km.

Saskatchewan Highways and Transportation uses road salt (sodium chloride) in winter maintenance to melt snow and ice. It also uses smaller amounts of road salt (calcium chloride) for dust protection on gravel roads. Road salt use in Saskatchewan is significantly lower than most other provinces, except for Prince Edward Island. New technologies are now being used to minimize salt contamination, such as building improved salt storage facilities, using new weather information systems to judge when salt is needed and using improved salt spreading equipment.

5.3.5 - Mining

Mining activities include the exploration, development, mining, processing, reclamation and decommissioning of mine sites. Mines and related infrastructure range in size from about 10 ha up to several hundred hectares. There are 31 active mine and/or mill operations in the province: 10 potash, 4 uranium, 3 coal, 1 gold, 2 base metal, 3 salt, 2 sodium sulphate, 2 potassium sulphate, 1 bentonite, 2 clay and 1 moss peat (see Appendix 2 for names and locations). Active and temporarily suspended mines and infrastructure occupy about 6,000 ha or about 0.01 per cent of the land area of the province. Coal, potash and uranium mining are of the greatest environmental concerns, due to their larger size, longevity and quantity of material mined or stockpiled.

Table 5.2 shows the active mine and mill operations in Saskatchewan for the years 1995-2002. The numbers have been fairly constant

Table 5.2 Saskatchewan Active Mine/Mill Operations, 1991-2002

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Potash	10	10	10	10	10	10	10	10	10	10	10	10
Uranium	3	3	3	2	2	2	2	2	3	4	4	4
Coal	5	6	6	5	5	5	5	5	3	3	3	3
Gold	3	2	1	1	2	3	3	2	2	1	1	1
Metal	1	1	0	0	0	0	2	2	2	2	2	2
Salt	3	3	3	3	3	3	3	3	3	3	3	3
Sod Sulph	6	5	5	5	5	5	5	4	3	3	2	2
Pot Sulph	0	1	1	1	1	1	2	2	2	2	2	2
Total	31	31	29	27	28	29	32	30	28	28	27	27

Footnotes: Table does not include quarry operations for silica sand, clay, bentonite, and horticultural peat.
The decrease in the number of coal mines from 5 to 3 in 1998-99 is the result of a consolidation of the mining operations and does not represent reduced production.
Abbreviations: Sod Sulp: Sodium Sulphate; Pot Sulp: Potassium Sulphate.
Source: Saskatchewan Industry and Resources, 2002.

The environmental pressures and impacts generated by mining activities depend on the type of mines (surface or underground) and the material being mined. Environmental impacts also range from local site-specific disturbances to soils, vegetation, wildlife, water and air to impacts covering wider areas. In particular, air emissions, water effluent disposal and road construction can lead to environmental impacts far from the mine itself. If not properly managed and regulated, mining-related environmental impacts may include soil erosion that results in sedimentation buildup in waterbodies, thereby damaging hydrological regimes and aquatic ecosystems. Harmful contaminants from tailings may leach from soil into waterways and enter food chains.

5.3.6 - Oil and Gas Development

Initial exploration for oil and natural gas consists of seismic geophysical surveys to locate targets for further investigation. In most areas of the province, the seismic surveys are done along existing roads to minimize cost and impact. In the north, new survey lines and roads are often cut. In other cases, the surveys are carried out over farm or ranch land with the owners' permission. Many areas of the province are criss-crossed with buried flow lines and larger pipelines used to transport gas and oil. Some of the impacts affecting the land include accidental oil spills, transport line ruptures and disposal of saline water from deep groundwater pockets during exploration. Oil spills can also result from truck and rail transportation of oil, thereby contaminating soil and waterbodies. Local impacts may include disturbances to soils, vegetation and wildlife.

On an annual basis, the amount of production and the number of wells drilled are closely related to the prices of the commodities. However, as can be seen in Table 5.3, there has been a significant overall increase in crude oil production and well drilling over the 1991-2001 period. Natural gas production and drilling also show a positive, but more subdued, trend. This results in an increase in the amount of land that is used for oil and gas exploration and production and a corresponding increase in the potential for other impacts and accidental spills.

Table 5.3 Oil and Natural Gas Statistics for Production and Wells Drilled in Saskatchewan, 1991-2001

	1991	1992	1993	1994	1995	1196	1997	1998	1999	2000	2001
Crude Oil											
Production	78	84	94	108	118	132	148	146	137	153	156
Wells	672	632	1,315	1,421	1,881	2,539	3,608	1,064	1,391	2,396	1,925
Natural Gas											
Production	7,320	7,474	7,667	8,519	8,715	8,066	7,818	7,694	7,907	8,148	8,263
Wells	461	211	969	1,000	268	369	327	634	1,038	1,209	1,409

Footnote: Crude oil production in million barrels; natural gas production in million cubic metres.
Source: SEM, 2001.

An active oil or natural gas well site and related infrastructure averages about 4 ha in area. As there are 40,344 active or temporarily suspended well sites in the province, they occupy an estimated 161,376 ha or 0.28 per cent of the land area of the province. Oil and gas wells have a high, but temporary, impact on the land. Rehabilitation of all well sites is required.

5.3.7 - Sand and Gravel Extraction

Maintenance of the road system and general construction activities create a continuous demand for sand and gravel. On Crown land, extraction is conducted under five-year leases, except for rural municipalities and Saskatchewan Highways and Transportation, which have leases for 21 years. There are a total of 586 sand and gravel/quarrying surface leases issued in the province, 352 of them in Northern Saskatchewan. These leases occupy approximately 5,238 ha of land. There are also numerous gravel pits on private lands. Sand and gravel pits affect the character of the landscape, disturb the flora and fauna of the area and take land out of agricultural or forestry use.

5.4 - SELECTED INDICATORS OR MEASURES OF LAND AND SOIL QUALITY

Although there are a range of human activities that impact the quality of land and soils, it is not possible to monitor all of these impacts. Rather, managers select certain indicators or measures that are monitored or tracked to assess how soil quality or condition in the province is changing. The following section provides information on existing indicators and measures. Work is ongoing to develop, improve and refine suitable indicators.

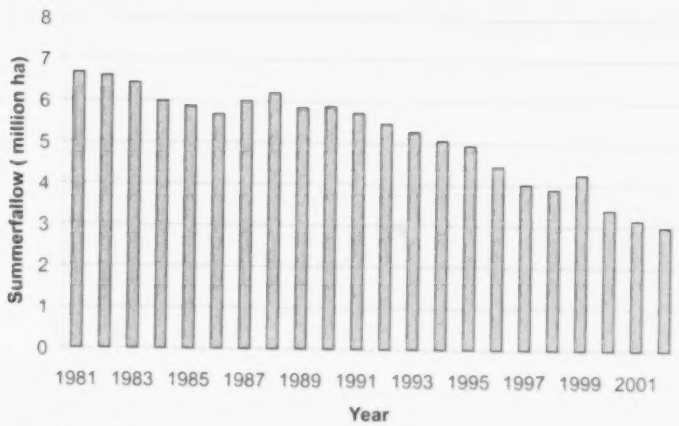
5.4.1 - Use of Improved Land Management Practices

The key aspects of soil health on the prairies include soil organic matter, soil salinity, soil structure, water erosion and wind erosion. According to the 1997 State of the Environment report for the Prairie Ecozone (SERM, 1997), organic matter levels on the prairies were estimated at one time to have declined by 50-70 per cent since virgin land was first cultivated. However, more recent studies indicate losses of 15-30 per cent in uneroded soils. Most farmland has less than 1 per cent of area affected by salinity; however, there are locations where salinity can affect up to 15 per cent of the land base. Approximately 5 per cent of cultivated land in the Prairie Ecozone is at risk of water erosion losses exceeding established tolerable limits, while about 27 per cent of cultivated land is at high to severe inherent risk of wind erosion.

Recent census data show that farmers are now reversing the loss of organic matter and decreasing water erosion and wind erosion by using different farming practices including zero tillage and by decreasing the amount of land in summerfallow.

Figure 5.2 indicates a decrease of greater than 50 per cent in the amount of land in summerfallow over the past 20 years.

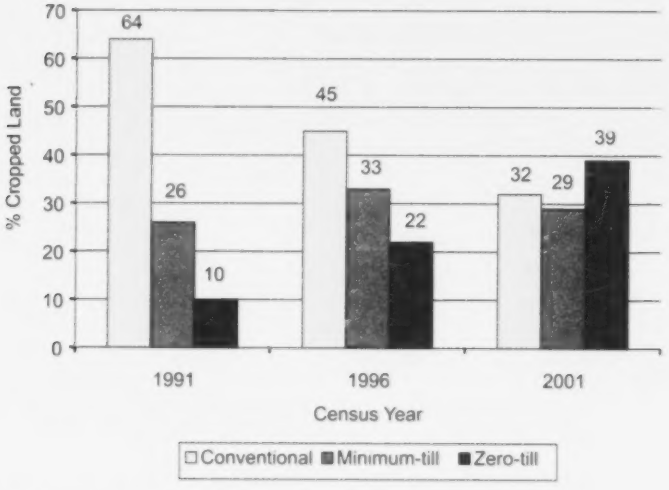
Figure 5.2 Saskatchewan Summerfallow Area, 1981-2002



Source: SAFRR, 2002

Between 1991 and 2001, Saskatchewan's area under zero tillage management increased from 1.3 million to 5.5 million hectares. The total area under reduced tillage systems (including both zero and minimum tillage) increased from 4.7 to 9.5 million hectares, representing over 67 per cent of the total cropped area in the province (Figure 5.3).

Figure 5.3 Adoption of Reduced Tillage Practices in Saskatchewan

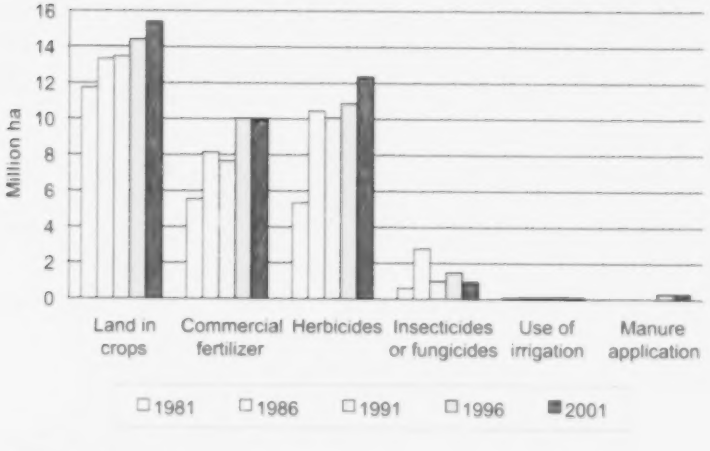


Source: Statistics Canada, 2001a.

5.4.2 - Use of Fertilizers and Pesticides

The *2001 Census of Agriculture* documents the number of hectares in Saskatchewan on which pesticides and fertilizers were used: 9.9 million hectares (41 per cent) were treated with commercial fertilizer, 12.3 million hectares (51 per cent) were treated with herbicides, 931,000 ha (4 per cent) were treated with insecticides and 931,000 ha (4 per cent) were treated with fungicides (Figure 5.4). Manure was applied on 265,000 ha.

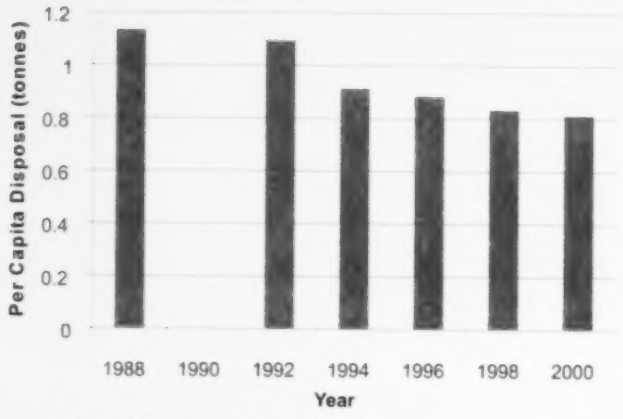
Figure 5.4 Saskatchewan Selected Land Management Practices



Footnote: 1996 and 2001 is insecticide hectares only.
Source: Statistics Canada, 2001a.

Overall, the extent of chemical application has increased in Saskatchewan over the past 20 years. This increase is correlated with an increase in the amount of cropland. The amount of land treated with commercial fertilizers has increased by over one-third from 1981 to 2001, while land treated by herbicides has more than doubled. Insecticides and fungicides have been used less extensively and have varied in their land coverage over the years. The amount of land treated with manure has increased, although the extent of its use is minimal. In the analysis of these trends, it is important to understand that the numbers do not reveal the volume of chemicals/manure applied to the land, but rather the extent (total area) of their coverage. The volume of chemicals used is largely undetermined.

Figure 5.5 Saskatchewan Waste Reduction



Footnote: There is no data available for 1990
Source: Statistics Canada, 1994, 1996, 1998, 2000

5.4.3 - Waste Reduction

The production and handling of waste is not a direct indicator of soil health. However, the number of landfills and the type of material that goes into landfills are of concern because, if not managed properly, there is the danger of leachate from landfills contaminating soils and groundwater. In essence, any reduction in the number of landfills and amount of waste going to landfills is a positive sign for protecting soils.

Saskatchewan has been effective in reducing the amount of waste generated per person. Economic growth in the late 1980s to the late 1990s was at approximately 24 per cent (Saskatchewan Bureau of Statistics, 1999), while per capita waste generation was reduced by over 26 per cent (Statistics Canada, 1994, 1996, 1998, 2000). Taken together, this equates to a waste reduction of over 50 per cent during that time period. See Figure 5.5.

5.4.4 - Contaminated Sites Cleaned Up

Contaminated sites are areas where the soil has been contaminated by what can be a wide range of contaminants. An inventory of contaminated sites within the province resulted in the identification of six high-risk contaminated sites (see list below) that were selected for cleanup action. Four of these sites have been cleaned up and the Woodland Campus and the Northern Petroleum Refinery property are slated for cleanup in 2003-04.

- **IPCO herbicide formulating plant**: This site, located near Saskatoon, was contaminated with heavy metals and hydrocarbons. The cleanup was completed during the 2000-2001 fiscal year.
- **Northern Petroleum Refinery**: This is an old petroleum refinery site located at Kamsack. The site contains a waste oil pit, which is scheduled for cleanup in 2003-2004.
- **NWR Salvage property**: NWR was a site for the salvage of batteries, wire insulation and tires. Contamination was cleaned up during 2001-2002.
- **Shragge Steel**: Shragge Steel is a former metal salvage operation located in Regina. The site was contaminated with heavy metals and hydrocarbons. The cleanup of this site was completed during the 2000-2001 fiscal year.
- **Waite Fisheries**: Waite Fisheries is a former fish processing plant. Contamination from fuel supply for diesel generators was cleaned up in 2000-2001.
- **Woodland Campus**: The Woodland site is contaminated with wood treatment chemicals. Completion of the cleanup is scheduled for 2003-2004.

In addition, a number of lower risk contaminated sites are in the cleanup process. Also, 400 abandoned fuel storage tanks have identified across the province: 371 sites have been assessed, and 70 sites have been cleaned up.

5.4.5 - Cleanup of Accidental Spills

Each year a number of accidental spills occur in the province due to traffic accidents, railway spills, leaking storage tanks, etc. Common categories used to classify spills include acid, base, asphalt, crude oil, diesel, fertilizer, gasoline, heating oil, industrial waste, natural gas, other oils, PCBs, pesticides, propane, radioactive, sewage, transformer oil, used oil and waste oil. These spills have the potential to contaminate soils as well as seep into groundwater. In 2001, Saskatchewan Environment's Spill Control Program responded to 278 spill incidents (Table 5.4).

Table 5.4 Number of Spills in Saskatchewan

Year	# of Spills
1981	234
1986	343
1991	372
1996	519
2001	278

Data Source: Saskatchewan Environment

There are strict procedures to follow when cleaning up these spills. The majority of spills can be cleaned up right away; however, some may take longer depending on the extent and toxicity of the spill.

5.5 - POTENTIAL RISKS TO ECOSYSTEM AND HUMAN HEALTH

In addition to changes to the quality of land and soils as a result of human activities, ecosystem and human health can be affected by specific activities or the combination of activities relating to land management. Approaches to assessing ecosystem health and the linkages between human health and the environment are still in their infancy; however, general information and trends are beginning to appear. Some potential risks to ecosystem and human health are presented in the following section but this is a very preliminary attempt to discuss ecosystem and human health.

5.5.1 - Desertification of Land

Salinization and loss of fertility reduce the health of soils and, consequently, the health and vitality of native plants and ecosystems in general. Desertification resulting from increased drought and reduced resilience of agricultural and forested lands following crop production and harvesting can seriously jeopardize ecosystem health. If the land becomes less productive and fertility levels decline, the negative economic implications to Saskatchewan are likely to become more serious. Although improved farming practices are helping to improve soil quality, the impacts of climate change may stress soils to the extent that some desertification of land may occur.

5.5.2 - Human Exposure to Pesticides and Herbicides

Farmers are at risk of having their health affected by pesticides they use in their farming operations. Pesticides may harm the genetic makeup of organisms (including humans) and cause mutations or certain cancers, depending on the type of exposure, type of pesticide, dose of exposure, time in lifespan at which the exposure occurs and the genetic makeup of the individual. The risk is elevated by exposure to multiple herbicides, insecticides and fungicides. Health research in Canada has shown that exposure to pesticides significantly increases the risk of non-Hodgkin's lymphoma, Hodgkin's disease, multiple tumors of the bone marrow and connective tissues, and prostate cancer (Institute of Agricultural Rural and Environmental Health, 2002; McDuffie et al., 2001).

It is difficult to determine the effects of lower doses of pesticides on the general public because of all the other substances to which people are exposed.

5.5.3 - Bio-accumulation of Toxic Substances

Persistant organic pollutants are toxic organic compounds that break down slowly in air, water and soil. They include polychlorinated biphenyls (PCBs), chlorinated dioxins and furans, and organochlorine pesticides like dichlorodiphenyltrichloroethane (DDT) and toxaphene. Although these chemicals are no longer used in Canada, they are still found throughout the environment and are still used in other parts of the world. They build up in fatty tissues of organisms and bio-accumulate. Therefore, concentrations are higher in animals like predators that are higher in the food chain. These chemicals or their by-products have also been found in mothers' breast milk. Persistant organic pollutants enter the food supply by way of atmospheric deposition on farmland or by the spreading of untreated sewage on fields used in food production.

Persistant organic pollutants and other chemicals, including pesticides currently in use, can be endocrine disruptors, as can natural and synthetic hormones released into the environment through various industrial processes, such as agricultural activities, pulp mill effluents, mining and municipal effluents. They are found in plastics, emissions from incinerators and in some metals. They are also released through pharmaceutical use (e.g., the use of estrogens for contraception and hormone replacement). They are spread through food, water and air. Endocrine disruptors upset the complex chemical messenger systems that regulate and balance body functions. There is now evidence that there are health effects at much lower doses of exposure than previously thought. For example, low level, or "background," exposure to some pesticides can reduce a frog's ability to resist disease dramatically. It is also being found that very low levels of disruptors can cause reproductive effects in wildlife and humans. Overall, little is known about the scale of effects and exposure routes, and much of the evidence is circumstantial.

5.6 - KEY MANAGEMENT ACTIVITIES AND PROGRAMS

As human activities occur and change, environmental managers implement a variety of management activities and programs to alleviate problems and protect or restore soil quality. Key management activities and programs relating to land and soils are outlined in the following section.

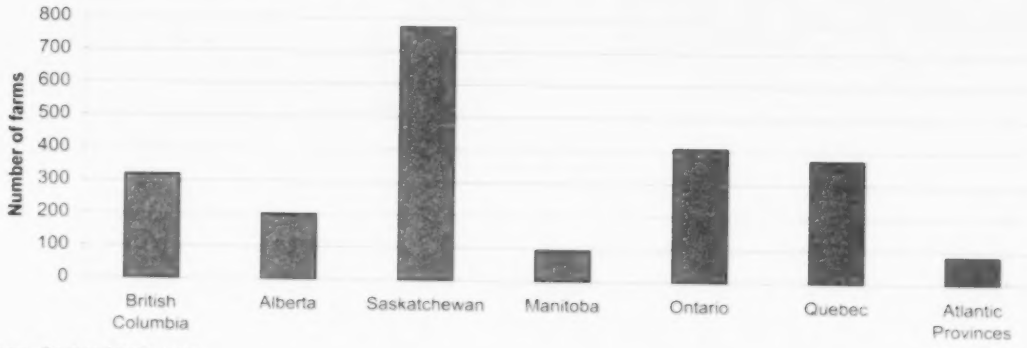
5.6.1 - Soil Management Practices

Government efforts and changes in farming practices and technologies have resulted in improved management of Saskatchewan soils. Effective programming and excellent working relationships have developed under federal-provincial agreements such as the National Soil Conservation Agreement (Save Our Soils), the Agricultural Green Plan and the Agri-Food Innovation Fund. These programs fund research, demonstrations and communication activities. Inventors also developed low disturbance systems that enable seeding into standing stubble. Several producer soil conservation associations have been formed. Direct-seeding technologies have been refined, and several of the province's equipment manufacturing companies have developed into major enterprises employing hundreds of people. Saskatchewan manufacturers now export seeding equipment around the world.

5.6.2 - Organic Farming

In response to a societal desire for pesticide-free food and/or a pesticide-free workplace, organic farming is becoming quite popular and profitable, growing by approximately 20 per cent per year (Statistics Canada, 2001a). Organic agriculture involves a holistic approach to farming that integrates biological and cultural management techniques. A farm is classified as organic if it meets the criteria stipulated in a set of guidelines known as an organic standard. The 2001 Agricultural Census enumerated 773 Saskatchewan farms that produced at least one category of certified organic agricultural products. These farms represented almost one-half of the Canadian total (Figure 5.6). A survey commissioned by Saskatchewan Agriculture and Food in the fall of 2000 found that Saskatchewan had over 1,000 organic producers. Currently, the organic industry in Saskatchewan consists of approximately 364,200 ha (Statistics Canada, 2001a). Most of the organic farms grow field crops, but there are also organic fruits, vegetables, animal products and herbs.

Figure 5.6 Number of Organic Farms in Canada



Source: Statistics Canada, 2001a.

5.6.3 - Integrated Pest Management Programs

Integrated pest management refers to use of a variety of techniques to suppress pests (e.g., plant diseases, insects and weeds) effectively, economically and in an environmentally sound manner. It is the basis of current pest control recommendations and extension materials used in Saskatchewan. It can involve a combination of biological, cultural, mechanical, behavioral and chemical measures.

Integrated pest management benefits the producer by reducing risk and lowering production costs, while maintaining healthy crops. Saskatchewan producers are already implementing many integrated pest management practices.

5.6.4 - New Forestry Harvesting Practices

Saskatchewan Environment, with the input of forest companies, is currently developing forestry standards and a monitoring program aimed at creating forest management practices that more closely emulate the effects of forest fires. The long-term objective will be to harvest the forest in patterns that more closely replicate patterns created on the landscape by fire. Harvest blocks will leave more green areas (to model the skips made by fire), less of the land base will be disturbed by roads and dead wood, and slash (debris) will be managed to create a more even distribution of nutrients on the harvest blocks.

5.6.5 - Agroforestry

Agroforestry is a land use system that incorporates the deliberate use of woody perennials on the same unit of land as agricultural crops and/or animals. Agroforestry systems allow for the concurrent production of trees and crops on the same land and include woodlots, multi-story cropping or forest farming, shelterbelts, riparian buffers and alley cropping.

Properly designed agroforestry systems protect crops and forage from natural disturbances, increase their production, protect soil and water resources, conserve energy, improve ecosystem "richness," and create additional wildlife habitat and landscape diversity. Riparian buffer strips, which are natural or re-established streamside forests made up of trees or shrubs, can reduce bank erosion and protect aquatic environments.

In 2001, the Saskatchewan Forest Centre, a non-profit corporation located in Prince Albert, was established with funding from the Government of Canada and the province. The two levels of government agreed to contribute $14 million over five years. The centre will promote the development of the forestry sector and value-added processing of wood products in Saskatchewan. Agroforestry is included in the centre's mandate and may play an important role in meeting the demand for wood fibre in future years.

5.6.6 - Regional Solid Waste Management

An evaluation of two pilot projects conducted in 1999 determined that regional waste management is feasible in Saskatchewan. In fact, the regional approach was found to be more economical than individual community waste management systems operated in compliance with today's environmental requirements (SERM, 1999).

The Centenary Fund, established in 2000 to help clean up contaminated sites in the province and to enhance the environment in preparation for the provincial centennial in 2005, will provide $2.3 million over four years to assist emerging regional systems in developing capital projects. Saskatchewan Environment has received applications for the 2002-03 year from the following regional waste management systems: Red Coat Waste Resource Authority in southeastern Saskatchewan, Parkland Regional Waste Management Authority (Preeceville/Kamsack/Canora area) and Saskatoon Regional Waste Management Association.

The Centenary Fund has also supported six existing regional waste management systems serving a population of 132,067. This accounts for 13 per cent of the provincial population. This program is an excellent example of producers, industry, non-government agencies and different levels of government working together to carry out successful initiatives.

5.6.7 - Waste Recycling Programs

Saskatchewan adopted the 4Rs (reduce, reuse, recycle and recover) as a waste minimization strategy with the advent of the Conservation Strategy (Saskatchewan Round Table on Environment and Economy, 1992). Recycling is a strategy that can be most successful if adopted at the municipal level. It results in less waste at landfills as materials are converted into new products.

SARCAN Recycling, under a contractual agreement with Saskatchewan Environment, is the recycling division of the Saskatchewan Association of Rehabilitation Centres (SARC), a non-profit, provincial coordinating and advocacy organization that represents 69 independent member agencies. These agencies are dedicated to improving educational, training and employment opportunities for persons with disabilities. SARCAN recycling operates 70 beverage container collection depots in 62 communities, as well as two processing plants (located in Regina and Saskatoon) and one administration centre (located in Saskatoon). SARCAN employs more than 365 full time staff and an additional 98 seasonal casual employees, most of whom have disabilities or were former recipients of social assistance.

Since its inception in 1988 and up to March 31, 2002, SARCAN has collected and recycled two billion beverage containers. Aluminium is made into new beverage cans; plastic is made into polyester fabric for carpets, clothing and fibre fill for parkas and sleeping bags; glass is recycled into new bottles, reflective beads for highway markings and fibreglass insulation; and steel is converted into new steel pipe and rolled steel products. See Table 5.5 for numbers of containers recycled.

Table 5.5 Beverage Containers Recycled in Saskatchewan

Fiscal Year	Beverage Containers Collected and Recycled	Recovery Rate %
1997-1998	186,243,815	96
1998-1999	206,393,492	94
1999-2000	203,861,149	86
2000-2001	202,176,225	85
2001-2002	217,024,511	83
5-Year Total	1,015,699,192	87

Data Source: Saskatchewan Environment

Saskatchewan businesses and residents generate approximately 20 million litres of used oil, 2.2 million filters and one million kilograms of oil containers every year. Before the used oil material recycling program was introduced, less than half the used oil was collected and recycled, and most oil filters and oil containers were discarded to waste. See Table 5.6 and Figure 5.7 for the numbers of used oil materials being recycled.

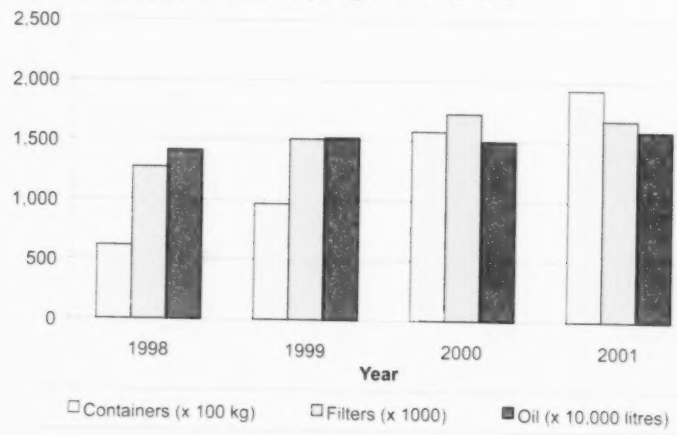
Table 5.6 Used Oil Material Recycling in Saskatchewan, 1998-2001

	1998	1999	2000	2001 (%)	Total
Oil Containers (kg)	61,400	96,550	157,970	193,425 (19)	515,450
Oil Filters (million)	1.27	1.51	1.73	1.68 (76)	6.35
Used Oil (million litres)	14.1	15.2	15.0	15.9 (79)	63.08

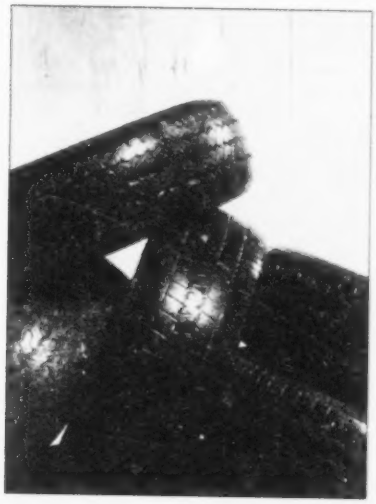
Source: SARRC, 1998, 1999, 2000, 2001

Saskatchewan's used oil collection program is operated by an independent third party organization called the Saskatchewan Association for Resource Recovery Corporation (SARRC). The first full year of the program was 1998. As of December 2001, there were 105 SARRC members. The organization operates 34 EcoCentres, which complement over 250 used oil collection facilities in over 150 Saskatchewan communities.

Figure 5.7 Used Oil Material Recycling in Saskatchewan



Source: SARRC, 1998, 1999, 2000, 2001



Used tires are also recycled in Saskatchewan. Tires take up a great amount of space in landfills because they retain many of their original characteristics, such as size and shape. Tires are designed not to break down or degrade under normal conditions. If they are burned they release toxic chemicals, which poison the air, soil and water.

The Scrap Tire Management Program is operated by an independent third-party organization called the Saskatchewan Scrap Tire Corporation (SSTC). During phase 1 of the program, the corporation primarily managed new tires entering the program. During phase 2, SSTC began collecting and processing existing tire stockpiles at landfills (Table 5.7).

Table 5.7 Tires Collected and Recycled in Saskatchewan

Year	Phase 1 Tires Collected	Phase 2 Tires Collected (PTE)	Recycled Tires (kg)
1997	360,371	0	322,665
1998	375,755	0	297,600
1999	505,640	220,341*	544,312
2000	560,067	302,294	11,863,776
2001	577,522	61,831	7,601,463
Total	2,379, 355	584,466	20,629,816

*Footnotes: *Represents scrap tires that were collected during the first year of Phase 2 of the program. No statistics were kept on these tires as they were shipped out of the province for disposal.*
Data Source: Saskatchewan Environment

Scrap tires are recycled into such products as playground equipment, vehicle ramps, livestock feeders, parking curbs, flooring, interlocking bricks and alternative fuels.

Another waste issue that has been addressed involves used pesticide containers. Saskatchewan farmers generate several million empty plastic pesticide containers each year. Improper disposal of these containers has the potential to impact the environment. Therefore, a provincial program, operated by the Saskatchewan Pesticide Management Association, aims to provide a province-wide system to safely collect and recycle these containers. Containers collected are shredded and recycled into fence posts and guardrails or are used as an energy resource.

The original pesticide container collection program was initiated and managed by Saskatchewan Environment and Resource Management in 1983, with voluntary participation by rural municipalities as owners and/or operators of the collection sites. Since 1989, the Pesticide Container Collection Program has been managed by the Saskatchewan Pesticide Management Association and funded by the Crop Protection Institute (CPI), now called Crop Life Canada. In 2000, Crop Life Canada assumed total program management in Saskatchewan and started replacing rural municipality sites with dealer collection sites. By the end of 2001, there were 373 dealer collection sites established in the province, along with the 191 rural municipality collection sites. The total number of containers collected increased from 1.4 million in 1996 to nearly 1.9 million in 2001.

5.6.8 - Environmental Monitoring for Oil and Gas Activities

Saskatchewan Industry and Resources reviews applications and issues licenses to explore, drill for, and produce oil and natural gas. The department's environmental and safety standards program establishes guidelines for and monitors the drilling, production, operation, and site decommissioning and reclamation activities. Regular inspections and monitoring are carried out by personnel from four field offices to ensure that oil and gas exploration and development activities are being conducted in accordance with established guidelines, standards and policies, and to ensure that the overall impact on the environment is minimized.

5.6.9 - Contaminated Site Cleanup

There are a number of contaminated "orphan sites" in the province. These are contaminated sites for which responsible parties cannot be located or owners are unable to finance the remediation of the properties. In 1998, Saskatchewan implemented a strategy for addressing contaminated sites (SERM, 1998). It relies heavily on the "polluter-pays" principle, with a reduced emphasis on making the current owner of contaminated land responsible for cleanup of problems created by previous owners.

Saskatchewan Environment is taking positive steps to ensure that orphan sites are cleaned up, through money from the Centenary Fund. Several high-risk sites have been identified through site assessments and evaluations and are being targeted for cleanup, in partnership with local municipalities. The cleanup program has provided an opportunity for communities to make formerly contaminated properties economically productive again.

The Orphaned Fuel Storage and Sales Facility Cleanup Program, also under the Centenary Fund, has provided communities with financial assistance to clean up orphaned fuel storage sites. Saskatchewan Environment partnered with Saskatchewan Urban Municipalities Association (SUMA) and Saskatchewan Association of Rural Municipalities (SARM) to deliver a four-year program designed to clean up orphaned service stations.

Seventy-five abandoned mines in northern Saskatchewan are being assessed by Saskatchewan Environment, in co-operation with Saskatchewan Northern Affairs, and with funding from the province's Centenary Fund. The aim is to identify and rank any public health/safety risks and potential impacts that the former mines might have on the environment.

Under current legislation mines can no longer be abandoned. When mining companies start up, they undertake an extensive regulatory review process and public consultation plan regarding their proposed operating and close-out or decommissioning plans, and they also guarantee money has been set aside to clean up the site.

6 WATER

CHAPTER OVERVIEW

Key activities or events affecting water quantity and quality: agriculture, power generation, climate change, urban development, forestry and forest fires, mining and milling, oil and gas exploration and development, other industries and commercial businesses, watershed alterations. General impacts or effects of these activities are: discharges of pollutants, pathogens and pharmaceuticals, destruction of riparian areas, stream siltation, alteration of aquatic habitats, loss of aquatic species, eutrophication of waterbodies, reduced instream flows, flooding.

Selected indicators or measures of water quality: surface water quality index, drinking water quality, rural domestic water quality.

Potential risks to ecosystem and human health: waterborne diseases, water pollution.

Key management activities and programs: new legislation and standards, changes to water management, rural water quality advisory program, monitoring of communicable diseases, regulation of intensive livestock operations, mine waste storage and reclamation, stewardship programs.

General Observations and Trends:
Water is available for human use from surface water and groundwater. Surface water comes from rain and snow falling on the Saskatchewan landscape or from rivers fed by mountain streams to the west. Groundwater is available from underground aquifers and the water table, which is usually located within 100 m of the surface.

Major consumers of water are agriculture, power generation, industry, mining, oil and gas production, and municipal and domestic users.

Both surface and groundwater are subjected to various forms of contamination. Domestic sewage, agricultural irrigation and livestock production can contaminate both surface and groundwater. Forestry, mining and milling, and oil and gas production are all sources of contaminants, either from by-products of production or from land use activities. Watershed alterations cause thermal pollution and disrupt the dynamics of water flows, while industry, commerce and power generation can contribute to pollution or significantly disrupt water regimes.

Climate change will inevitably impact Saskatchewan's water supplies. Drought conditions are a constant factor in availability of water supplies and greatly influence the quality of water as well. Droughts may become more frequent as a result of longer summers and higher temperatures.

The Surface Water Quality Index is used as a method to monitor water quality in the three major watersheds in southern Saskatchewan. Water quality is generally fair to good in these watersheds.

Drinking water, treated for municipal systems, is generally in good condition and improving, but further enhancements are required. A bigger challenge is domestic water supplies to rural residents, where a great variety of problems associated with groundwater and surface water quality must be addressed.

The province has created the Saskatchewan Watershed Authority to develop new approaches to address water use and protection concerns. A Rural Water Quality Advisory Program was instituted in 1997 and has serviced over 2,100 rural households. The Saskatchewan Watershed Authority is also working with various stakeholders to nurture public stewardship programs for many of the province's watersheds.

6.1 - INTRODUCTION

The following chapter on water is organized into five main sections. It begins by providing general information on the province's hydrology. This is followed by a description of activities and events affecting surface and groundwater, indicators or measures used to assess the quality of water, potential risks to ecosystem and human health, and key regulations, activities and programs underway to address specific water issues.

This information is not intended to provide an exhaustive description of water quality and quantity throughout the province, but rather presents key information that is currently available. Work by government is ongoing as it develops adequate response and preventative mechanisms, particularly in providing safe drinking water to the people of Saskatchewan. Actions to address specific water quantity and quality issues continue over the long term.

6.2 - GENERAL DESCRIPTION

6.2.1 - Surface Water

Saskatchewan has three distinct surface runoff regimes: the Canadian Shield region, mountain-fed streams and the prairie-based region. In the Shield, water is generally more abundant due to greater amounts of precipitation, reduced evaporation and storage of water in numerous lakes. Ninety percent of the flow in the Saskatchewan River system is determined by runoff from the eastern slopes of the Rockies.

In the Prairie Ecozone, many of the streams are seasonal, with spring snowmelt typically contributing about 80 per cent of the annual flow. Annual evaporation commonly exceeds precipitation, and wide variations in temperature and precipitation produce droughts and flooding. Droughts can occur in the other regions as well; for example, from 1978-1992, the Boreal Shield Ecozone received below-average precipitation and the Churchill River experienced its lowest recorded flow. In general, though, the relative abundance of water is illustrated by comparing the average combined flow of rivers leaving each region annually: 42.5 million cubic decameters from the Shield, 20.5 million cubic decameters from the Saskatchewan River and only 1.1 million cubic decameters from the entire Prairie region.

6.2.2 - Groundwater

Groundwater is found between particles of rock and soil or in crevices and cracks in rock. The underground level below which all spaces are filled with water is called the water table. Above the water table, strata spaces are filled with air and water. Groundwater in this zone is called soil moisture. In Saskatchewan, the water table occurs usually within 100 m of the surface.

Aquifers are underground water-bearing formations that can produce useful quantities of water. They vary in size from a few hectares to thousands of square kilometres. In general, the susceptibility of aquifers to drought and seasonal variation decreases with depth. Deep aquifers are most likely not in equilibrium with the present climate.

Saskatchewan has two distinct geological regimes, namely the Canadian Shield (Boreal Shield and Taiga Shield ecozones) and Western Canada Sedimentary Basin (Prairie and Boreal Plain ecozones). Groundwater sources in the Canadian Shield are limited to surficial deposits, fault zones and the sandstone bedrock found in the Athabasca Plain. In the southern portion of the province, there is great variance in aquifer depth, thickness, texture and extent, all of which limits groundwater availability.

6.2.3 - Water Supply and Contamination

Natural variability in supply is exacerbated by human activities that use water or degrade water quality. Dams on streams and rivers reduce the amount of water reaching the ocean, increase evaporation and change the groundwater regime, water chemistry and temperature. Various land use activities modify and contaminate surface runoff with all manner of chemicals, eroded soil particles and treated waste. This contamination ends up in waterways, wetlands and groundwater.

Groundwater contamination can come from point sources (one location), where small quantities of pollutants can contaminate millions of litres of groundwater. The contaminant can also be carried with the groundwater into lakes and rivers. Groundwater contamination can last for generations and is very difficult to clean up.

6.3 - KEY ACTIVITIES OR EVENTS AFFECTING WATER QUANTITY AND QUALITY

Water is essential to Saskatchewan residents for agriculture (irrigation and livestock), power generation (thermal and hydroelectric), industry, mining, oil and gas production, and municipal and domestic uses. Table 6.1 summarizes the water consumption in the province by river basin and major user. The agricultural category includes estimates for irrigation and livestock. Oil and gas figures are for authorized water uses such as steam or water injection associated with oil and gas production. The mining category covers mining and milling. The industry and commerce values are for facilities with their own private surface or groundwater supply. Municipal and domestic use covers urban and rural users. Water use for thermal power generation is for forced evaporation from cooling reservoirs.

Table 6.1 Water Consumption by River Basin and Major User (mid-1990s)

River Basin	Agriculture	Oil & Gas	Mining	Industry & Commerce	Thermal Power Generation	Municipal & Domestic	Total	Percent of Provincial Total
				(million cubic metres)				
Souris	15.7	< 0.1	< 0.1	< 0.1	10.7	8.5	35.0	4.2
Missouri	76.3	0.3	0.1	Nil	5.9	1.2	83.8	10.1
Cypress Hills	29.0	0.3	Nil	Nil	Nil	1.2	30.5	3.7
Old Wives	52.6	< 0.1	0.5	Nil	Nil	2.5	55.6	6.7
Qu'Appelle	46.9	Nil	9.7	3.4	Nil	53.0	113.0	13.6
South Saskatchewan	286.0	1.9	7.7	Nil	0.5	55.8	351.9	42.3
North Saskatchewan	32.5	4.1	0.5	48.3	Nil	23.3	108.7	13.1
Saskatchewan	5.0	Nil	Nil	0.5	Nil	7.2	12.7	1.5
Assiniboine	5.6	Nil	1.0	Nil	Nil	5.2	11.8	1.4
L. Winnipegosis	2.4	Nil	Nil	Nil	Nil	1.3	3.7	0.4
Churchill/Athabasca	5.4	< 0.1	6.3	0.6	Nil	12.5	24.8	3.0
Total	557.4	6.7	25.8	52.8	17.1	171.7	831.5	
% of Total	67.0	0.8	3.1	6.3	2.1	20.6		

Data Sources: Saskatchewan Water Corporation and Prairie Provinces Water Board

6.3.1 - Agriculture

Irrigation is used, in some areas, to supplement or replace natural rainfall for growing crops. Only 0.73 per cent, or approximately 134,000 ha, of farmland in Saskatchewan is irrigated, but irrigation accounts for about two-thirds of all provincial water consumption. Table 6.2 summarizes irrigated land from 1990-2000.

The amount of surface runoff or return flow from irrigated fields varies greatly between land irrigated by gravity (more) and sprinklers (less). Return flow of irrigation water may contain high levels of salts and other pollutants picked up in the irrigation process. Gravity irrigation is gradually being converted to sprinkler, and all new projects are the sprinkler type. The amount of backflood and backflood drainage irrigation has remained essentially static.

Table 6.2 Irrigated Land in Saskatchewan

Year	Sprinkler[1] (ha)	Gravity[2] (ha)	Backflood[3] (ha)	Drainage[4] (ha)	Backflood/ Other[5] (ha)	Total (ha)
1990	62,884	26,004	18,615	18,803	673	126,979
1991	65,036	26,230	18,657	18,741	934	129,598
1992	65,986	26,040	18,598	19,043	764	130,431
1993	66,515	26,067	18,650	19,043	925	131,200
1994	65,986	26,041	18,632	19,071	919	130,649
1995	65,627	25,898	18,632	19,171	802	130,130
1996	67,996	24,591	18,817	19,263	914	131,581
1997	68,274	24,591	18,817	19,263	916	131,861
1998	69,449	24,593	18,817	19,263	916	133,038
1999	70,211	24,593	18,817	19,263	916	133,800
2000	70,636	24,598	18,838	19,280	952	134,304

Footnotes:
1. Pumped, sprinkler, throughout irrigation season. 2. Gravity, furrows, gated pipe, etc., throughout irrigation season. 3. Gravity, dyked and gated natural run, spring only. 4. Gravity, drained and gated low area, spring only. 5. Pumped, drip irrigation, etc., throughout irrigation season.
Sources: Saskatchewan Agriculture and Food, 1993, 1998, 2000.

Livestock also require drinking water. The numbers of livestock and poultry on Saskatchewan farms are increasing. There are currently 2.6 million cattle and calves, 2.1 million pigs, 104 thousand sheep and lambs, 66 thousand horses and 17 million chickens in the province. The raising of cattle, pigs and chickens is also becoming more intensive (intensive livestock operations [ILOs]), a practice that requires large supplies of water from local sources.

Waste and by-products from ILOs can potentially enter water systems through leakage from manure storage lagoons, runoff from soils where manure has been applied and the percolation of water through soils into groundwater. Unrestricted grazing and drinking from streams and other waterbodies can have a substantial and detrimental impact on riparian areas and downstream water quality. The eutrophication of waterbodies, where nutrients promote extensive algae growth, often results from agricultural activities, depriving the waterbody of needed oxygen. Pathogens (disease-causing organisms) as well as remnants of pharmaceuticals such as vaccines, antibiotics and hormones from livestock waste can also be transmitted into waterbodies, posing risk to animal and human health.

The cultivation of soil and the application of fertilizer and pesticide chemicals can also lead to deterioration in water quality. Surface runoff can erode the land surface and carry topsoil and chemical residues into waterways, causing toxicity to organisms, suffocation of fish and other delicate organisms and general eutrophication problems. Chemicals may also leach into groundwater and, potentially, into drinking water.

6.3.2 - Power Generation

Power generation is one of the largest users of water in the province. For example, thermal power represents about 2 per cent of the total amount of water consumed in the province (Table 6.1); however, intake is nearly 150 times this amount and water flow through hydroelectric turbines is nearly 25 times the intake of thermal power plants (Table 6.3).

Table 6.3 Summary of Water Intake for Power Generation

River Basin	Hydroelectric	Thermal	Total	Percent of Provincial Total
		(million cubic metres)		
Souris	Nil	760.1	760.1	1.2
Missouri	Nil	1,742.4	1,742.4	2.8
Cypress Hills	Nil	Nil	Nil	Nil
Old Wives	Nil	Nil	Nil	Nil
Qu'Appelle	Nil	Nil	Nil	Nil
South Saskatchewan	8,426.4	0.6	8,427.0	13.4
North Saskatchewan	Nil	Nil	Nil	Nil
Saskatchewan	30,317.1	Nil	30,317.1	48.3
Assiniboine	Nil	Nil	Nil	Nil
L. Winnipegosis	Nil	Nil	Nil	Nil
Churchill/Athabasca	21,565.2	Nil	21,565.2	35.4
Total	60,308.7	2,503.1	62,811.8	
% of Total	96.0	4.0		

Data Source: Saskatchewan Watershed Authority

6.3.3 - Climate Change

Climate change prediction scenarios consistently indicate significant impacts to both water quantity and quality, particularly on the prairies. Higher temperatures will lead to greater evaporation and less available surface water for animals, plants and humans. Greater pollution of waterbodies may also result because contaminants become less distilled. Due to their reliance on precipitation, water levels of waterbodies and streams in prairie watersheds and surficial aquifers exhibit direct correlation with cycles of floods and droughts. More frequent severe weather events can lead to floods that wash sewage and disease-causing organisms into water supplies.

6.3.4 - Urban Development

From 1990-2000, the number of persons living in cities, towns and villages grew from about 74 per cent to over 80 per cent of the total population. Over the same period, more than 50,000 fewer people were living in rural Saskatchewan, a drop of nearly 25 per cent. Residential, commercial, institutional and urban industrial development is increasing the urban demand for water and associated storm and sanitary sewer discharges. Municipal and domestic users presently use about 20 per cent of all water consumed in the province. Roughly 50 per cent of municipal water use is by cities with a population of over 100,000.

Urban centres also discharge large amounts of liquid industrial waste and underground leachates. Although the major cities in Saskatchewan implement tertiary sewage treatment, which effectively removes solid waste and pathogens, there is always the risk of contamination of waterways, caused by a malfunction. Smaller urban centres that do not treat their sewage as thoroughly can cause eutrophication of waterbodies and possible contamination of groundwater. As well, industries may release harmful contaminants including oil, acids and heavy metals into waterways. Landfills, if not properly constructed, can pose a risk to groundwater if contaminants from waste leach through to the water table.

Water use by urban areas can seriously jeopardize aquatic ecosystems by reducing instream flows. Discharges from periodic cleaning and disinfecting of water pipelines, as well as treatment plant effluent can pollute waterways. Development alters the natural landscape, which may change surface runoff patterns and introduce pollutants to aquatic ecosystems.

6.3.5 - Forestry and Forest Fires

Forest harvesting and forest fires can accelerate the rate that water moves across the forested landscape. Since 1991, on average, about 500,000 ha of forest have burned each year. Over 24,000 ha of forest are harvested annually. The construction of roads and the removal of vegetation increase the amount of erosion and runoff into streams, increasing the sediment load, and adversely affecting riparian areas. The removal of the forest cover also temporarily reduces evapo-transpiration. The peak flow and total amount of surface runoff are accordingly increased, as well as the amount of groundwater. This effect diminishes as new growth becomes established.

Processing activities, after trees are harvested, can also contribute to the contamination of waterbodies. Pulp mills, for example, may contaminate waterways by dumping effluents that can reduce the amount of oxygen in water. Effluents from wood processing mills are closely monitored and tightly controlled in Saskatchewan. The pulp mill at Meadow Lake produces primarily solid waste, resulting in very little liquid effluent production. Pulp, paper and other forest product mills account for nearly 60 per cent of industrial surface water use in the province.

6.3.6 - Mining and Milling

Mining operations in Saskatchewan account for just over 3 per cent of provincial water consumptive use. Potash and uranium mining operations use large amounts of water. For example, the Belle Plaine and Patience Lake potash mines inject water underground to dissolve the potash and also use water in the milling process. Any water that is released must meet environmental quality standards.

In the mining process, fuels, oils and drilling fluids can spill or leak into the ground, eventually contaminating groundwater or nearby waterbodies. In open pit mining, large areas of vegetation, soil and rock overburden material can erode and become a source of sediments, heavy metals and acid leaking into local waterways. The residual materials of the mining process, called tailings, have the potential to contaminate local waterbodies and the surrounding environment. As well, decommissioned mines, unless reclaimed, are potentially a source of contamination.

6.3.7 - Oil and Gas Exploration and Development

The oil and gas production sector uses less than 1 per cent of the water consumed in Saskatchewan. In the drilling of an oil or gas exploration well, water is used to produce a lubricant called drilling mud. Water is also commonly used to enhance oil recoveries from older producing pools. Water is injected into the oil reservoir of older wells to increase the reservoir pressure and displace more oil for recovery.

Surface and groundwater quality can be affected through accidental oil spills and disposal of saline water from deep groundwater pockets during extraction. Toxins may also leak into surface and groundwater if drilling wastes are disposed of in unprepared sites.

6.3.8 - Other Industries and Commercial Businesses

Many industries and commercial enterprises use water in conducting business. Saskatchewan industrial and commercial enterprises, with their own private source of water, use about 6 per cent of all water consumed in the province. Some businesses rely on the recreational use of water in parks, campgrounds and wilderness areas. Outfitters rely on water for sport fishing, hunting and ecotoursim.

Industrial sectors produce harmful emissions, wastes or effluents that can have local, regional or even global impacts. The environmental impact varies at different stages of a product's life cycle. The transporting of industrial goods often involves accidental leaks and spills. Aerosols can dissolve in atmospheric water and become pollutants affecting water quality (acid rain). Liquid contaminants can evaporate and become air pollutants (volatile organic compounds). Solids can dissolve and effect water quality (landfill leachate). The improper disposal of oil by-products, such as oil filters and containers, can lead to the contamination of ground and surface water, since small amounts of oil in these by-products can contaminate large areas of water. Used oil materials also contain small quantities of toxic substances, such as trace metals, gasoline and polychlorinated biphenyls (PCBs).

6.3.9 - Watershed Alterations

Dams and control structures affect the quantity of water through redirection or changing the amounts of flow in rivers and streams. Over two-thirds of the water leaving the province is regulated by dams, such as the Island Falls Dam on the Churchill River and the Gardiner, Francois-Finlay and E.B. Campbell dams on the Saskatchewan River. Dams in British Columbia and Alberta also influence flows in the Saskatchewan River system and, to some degree, water levels in Lake Athabasca. In the south, flow in the Qu'Appelle River is regulated by seven control structures and by releases from Lake Diefenbaker. The Alameda and Rafferty dams regulate flow in the Souris River. Overall, there are about 8,000 licensed reservoirs in the prairie region of the province. The amount of water storage and number of dams and control structures has remained relatively constant since completion of the Rafferty and Alameda dams.

Channelization and dyking of minor waterways, to minimize flooding of the adjacent flood plain and increase the amount of land available for development or farming, is a historical practice in southern Saskatchewan. Few rivers, though, have been channelized. One exception is 96 km of the Qu'Appelle River, or one-quarter of its length, which has been dredged. However, the clearing and straightening of secondary streams is quite prevalent in Saskatchewan. There are currently 107 Conservation and Development Area Authorities that maintain over 3,000 km of ditches. Eight watersheds have watershed associations that sponsor water projects that involve channelization and/or control structures. Despite regulation to control private ditching, unauthorized drainage works continue throughout southern Saskatchewan.

Dams and control structures also affect water quality in a number of ways. The initial creation of a reservoir involves the flooding of vegetation, which can lead to high levels of toxic methyl mercury in the water as vegetation decomposes. Water quality downstream from the dam can be altered when water of different temperatures or water with too little dissolved oxygen is released from the reservoir. Dams also trap sediment, nutrients and contaminants in their reservoirs.

6.4 - SELECTED INDICATORS OR MEASURES OF WATER QUALITY

6.4.1 - Surface Water Quality Index

The Canadian Water Quality Index (CWQI), which was developed by a federal/provincial taskforce, is used to provide an understanding of complex water quality data. It incorporates three elements:

Scope - the number of variables not meeting Saskatchewan's Surface Water Quality Objectives (SWQO)
Frequency - the number of times these objectives are not met
Amplitude - the amount by which the objectives are not met

The index enables regulators to rate water quality against its desirable condition or state. The number provided by the index ranges from 0 (worst water quality) to 100 (best water quality).

Saskatchewan's application of the the Surface Water Quality Index (SWQI) allows the user to evaluate water quality parameters against the SWQO in four categories or uses:

Protection of Aquatic Life - fish, insect and plant life
Irrigation - irrigated crops
Livestock Watering - livestock growth and well-being
Recreation - bacterial and aesthetic quality parameters of the water

Once the SWQI value has been determined for a particular watershed use, water quality is ranked as one of the following categories:

Excellent: (Index value 95-100) - water quality is protected with a virtual absence of threat or impairment; conditions are very close to the desired objectives.
Good: (Index value 80-94) - water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from desirable levels.
Fair: (Index value 65-79) - water quality is usually protected but occasionally threatened or impaired. The conditions sometimes depart from desirable levels.
Marginal: (Index value 45-64) - water quality is frequently threatened or impaired. The conditions often depart from desirable levels.
Poor: (Index value 0-44) - water quality is almost always threatened or impaired. The conditions usually depart from desirable levels.

SWQI for Major Rivers in Saskatchewan
The SWQI has been applied to the South Saskatchewan, North Saskatchewan and Qu'Appelle rivers. The SWQI was applied for two uses and their associated objectives: "aquatic life and wildlife protection" (see Table 6.4) and "contact recreational uses" (see Table 6.5). These uses tend to be the most sensitive categories for evaluation.

Table 6.4 Objectives of the Saskatchewan Water Quality Index for Aquatic Life

Water Quality Parameter	Objective
Chloride Dissolved	100 mg/L
Arsenic Total	0.05 mg/L
Chromium Total	0.02 mg/L
Nitrogen - Total Ammonia	Based on pH and temperature
Mercury	0.0001 mg/L
Sodium - Dissolved	100 mg/L
pH	6.5 8.5
Oxygen - Dissolved	minimum 5 mg/L
2,4-D	0.004 mg/L
MCPA	0.0025 mg/L

Source: Saskatchewan Environment

Table 6.5 Objectives of the Saskatchewan Water Quality Index for Recreational Use

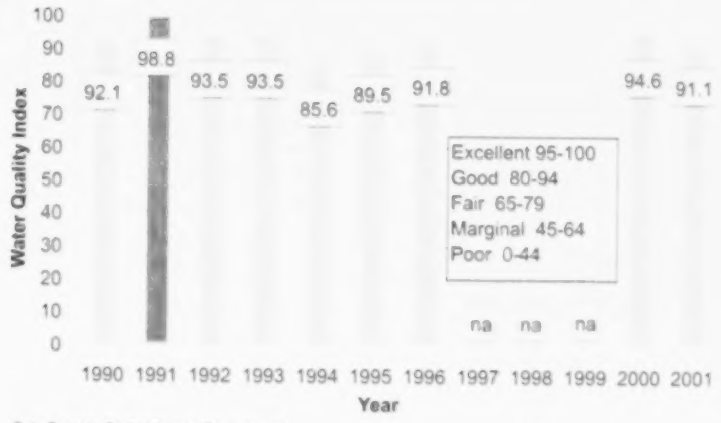
Water Quality Parameter	Objective
Fecal Coliforms	< 200 per 100 mL
Clarity	Water clear to depth of 1.2 m

Source: Saskatchewan Environment

Results of the SWQI Analysis
The South Saskatchewan River is a broad, swift-flowing river which includes Lake Diefenbaker. It originates in the Rocky Mountains and flows eastward into Saskatchewan, entering the province near Leader.

The SWQI ratings for the South Saskatchewan River in the "protection of aquatic life" category, for the years 1990-2001, range from good to excellent, showing little variation from one year to the next (Figure 6.1). These ratings are the mean of all stations on the river for that year. The SQWI could not be applied to the years 1997-1999 because of insufficient water quality data.

Figure 6.1 South Saskatchewan River - Saskatchewan Water Quality Index for Protection of Aquatic Life Category, 1990-2001

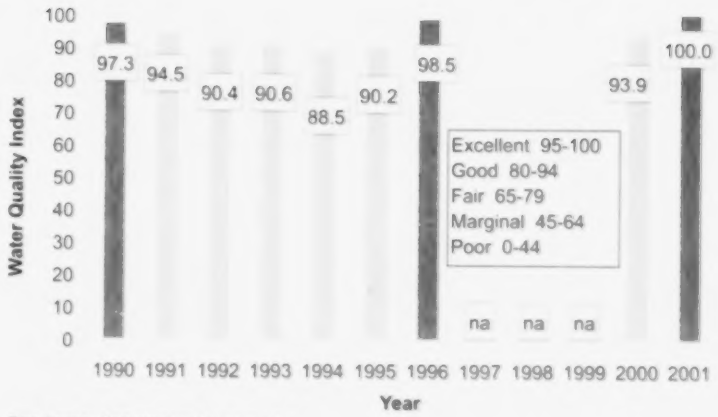


Data Source: Saskatchewan Environment

The North Saskatchewan River originates from snow and glacial melt waters in the eastern Rocky Mountains of Alberta. It flows through Edmonton and enters Saskatchewan near Lloydminster. There are no control structures on the North Saskatchewan River in Saskatchewan.

The SWQI for the North Saskatchewan River in the "protection of aquatic life" category, for the years 1990-2001, range from good to excellent, showing little variation from one year to the next (Figure 6.2). These ratings are the mean of all stations on the river for that year. The SWQI could not be applied to the years 1997-1999 because of insufficient water quality data.

Figure 6.2 North Saskatchewan River - Saskatchewan Water Quality Index for Protection of Aquatic Life Category, 1990-2001

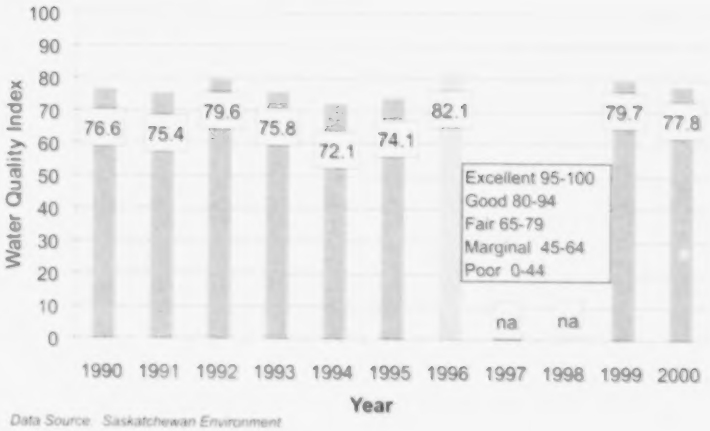


Data Source: Saskatchewan Environment

The Qu'Appelle River originates at the Qu'Appelle Valley Dam on Lake Diefenbaker and flows eastward to join the Assiniboine River near St. Lazare, Manitoba. The Qu'Appelle, under natural conditions, is an intermittent system with runoff from snowmelt as its major source of flow.

Figure 6.3 shows the mean SWQI ratings of all stations on the Qu'Appelle River for the years 2000-2001 in the "protection of aquatic life" category. The years 1997 and 1998 were omitted due to insufficient data. On the Qu'Appelle River, there are some factors that may occasionally impair the water for use by aquatic life. These include both human-caused and natural impacts - municipal treated effluent, high ionic groundwater infiltration, low flows under ice, declines in dissolved oxygen due to plant decomposition and high evaporation to surface area ratios. Overall, though, the ratings ranged from fair to good condition.

Figure 6.3 Qu'Appelle River - Saskatchewan Water Quality Index for Protection of Aquatic Life Category, 1990-2000



Data Source: Saskatchewan Environment

6.4.2 - Drinking Water Quality

Drinking water is one of the highest priority water uses in Saskatchewan. The quality of drinking water sources, particularly surface waters, is variable. Ranging from elevated levels of minerals, such as iron and manganese, to elevated levels of color or taste and odor-causing organic compounds, there are a number of potential aesthetic concerns with drinking water supplies. However, society is most concerned about water that affects human health.

Saskatchewan Environment has produced drinking water compliance reports for the years 1994-1995, 1999-2000 and 2000-2001 (SERM, 1996, 2000, 2001). These reports outline in some detail the quality of the municipal water supplies regulated by the department. In future years, Saskatchewan Environment will be producing annual drinking water compliance reports for submission to the legislature to formalize the tracking of provincial water quality. Approximately 544 municipal and other systems will be providing data to this monitoring program.

Bacteria Levels

Bacteriological performance is based on the number of regular sample results that are free of bacteriological contamination. Indicator bacteria include total coliforms, fecal coliforms and background bacteria. During the 1999-2000 fiscal year, 42 per cent of the water systems providing regular bacteriological samples were found to be free of bacteriological contamination. The 2001-2002 bacteriological samples indicated an improvement to 47 per cent being free of contamination.

The most common and effective means of disinfecting drinking water to ensure that no harmful bacteria or viruses are present is by the addition of chlorine, a process known as chlorination. If treatment is effective, a chlorine "residual" is achieved. This chlorine residual is required to remain in the water throughout the distribution system after the chlorine has reacted with substances in the water. This ensures that there is a safe chlorine concentration in the water to kill any residual bacteria before it reaches consumers.

During the 1999-2000 fiscal year, 53 per cent of the systems providing regular bacteriological samples also provided chlorine residual information that met the regulatory requirement at least 90 per cent of the time. The 2000-2001 free and total chlorine residual data indicated an improvement to 61 per cent of the systems.

Turbidity Levels

Turbidity is a good indicator of the performance of drinking water treatment, since it measures the overall clarity of the water after treatment for removal of particles. It is especially useful for assessing the quality of treated surface waters. A number of factors can cause turbidity levels to exceed drinking water guidelines in any given time period. Although some of the factors causing increased turbidity are common and do not pose increased risks, even one such occurrence during the year may cause a municipality to exceed the turbidity objective. It should also be noted that the turbidity objective has been reduced from 5 nephelometric turbidity units (NTU) to 1 NTU, making it more difficult to meet the compliance guideline. During the 2000-2001 fiscal year, 82 per cent of the samples submitted met the turbidity objective of 1.0 NTU (Saskatchewan Environment, 2002).

Minimum Treatment Requirements

Another broad measure of the safety of provincial drinking water relates to the number of systems that have the infrastructure in place to properly treat their water supplies. Saskatchewan Environment specifies minimum treatment criteria to be employed when treating groundwater and surface water. It is difficult to obtain scientific, detailed health-related information that links waterborne diseases to water treatment deficiencies. However, water treatment facilities can be considered a reasonable preventive measure for waterborne diseases. Therefore, the recording of the presence or absence of minimum treatment facilities is a useful broad measure of the potential health impact of drinking water systems in Saskatchewan.

For groundwater, the minimum treatment requirement of a source with acceptable bacterial content is disinfection. For surface water, the minimum treatment is coagulation, flocculation, sedimentation, filtration, disinfection and, sometimes, taste and odor control capability (other treatment mechanisms such as cartridge or other forms of filtration may also be acceptable in certain instances) (SERM, 1996).

When the number of communities employing minimum treatments was first reported in 2000, 93 per cent of Saskatchewan's municipal treated water systems met the minimum treatment requirement to provide safe drinking water. By October 31, 2001, 499 out of 528 (94.5 per cent) municipal water treatment systems met the minimum requirements for water treatment.

6.4.3 - Rural Domestic Water Quality

Well over 300,000 people or more than 30 per cent of the current population of Saskatchewan rely on private groundwater supplies. Rural water samples have been randomly collected under SaskWater's Rural Water Advisory Program. Details of the different kinds of problems experienced by private groundwater supplies are contained in a report by Sketchell and Shaheen 2001. The results from the first two years of data collection indicate that 35 per cent of the wells exceeded minimum standards for one or more health-related parameters, as established in the *Guidelines for Canadian Drinking Water Quality* (Health Canada, 1996).

The problems in groundwater pose real challenges to rural residents, who rely on using these sources for domestic water. Some of these groundwater problems also make the water very difficult to treat, or to use for other purposes such as agricultural needs. Alternative private supplies, such as collecting snow or rain in earthen ponds or dugouts, are commonly used in rural Saskatchewan. However, such small reservoirs pose other unique challenges and quite a different set of water quality problems. Dugout water quality is generally considered poor, largely due to very high concentrations of dissolved and particulate organic matter, microbiological contamination and potential toxins from cyanobacteria. Effective management and extensive filtering or other aggressive treatments are always necessary.

6.5 - POTENTIAL RISKS TO ECOSYSTEM AND HUMAN HEALTH

6.5.1 - Waterborne Diseases

Pollution of water with feces, either human or animal, and contamination of food, can lead to diseases of the gastrointestinal system, or diarrhoeal diseases, in all areas of the world. Clean water supplies and sewage systems lessen the likelihood of contracting these diseases, but between 1974 and 1996, more than 160 waterborne disease outbreaks were reported in Canada.

Cryptosporidium

Cryptosporidium parvum is a protozoan that lives in the intestines of animals and people, and occurs in animal and human wastes. Infection can occur by putting anything in the mouth that has been in contact with feces from an infected animal or human, including infected soil, food or water supply. Most surface waters contain *Cryptosporidium*, especially after heavy rains.

Cryptosporidium is a microscopic, single-cell parasite that is about 20 times smaller than the width of a human hair. During one stage of its life cycle, it lives in an egg-like form and can survive in water for months, so people may not become sick until months after the parasite first entered the water source. Chlorination does not effectively kill the parasite, but there are other water treatment methods to remove the organism. The main symptoms of infection are watery diarrhea, abdominal cramps, nausea, low-grade fever, dehydration, weight loss and headaches.

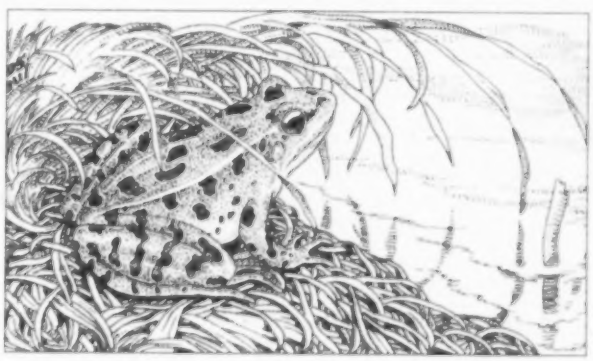
Saskatchewan experiences an average of 40 reported cases of *Cryptosporidium* per year. The water-related outbreak of *Cryptosporidium* in North Battleford accounts for the majority of the 771 laboratory confirmed cases in 2001. Increased awareness also led to an increased number of specimens being submitted for testing, whereas in previous years, individuals with gastroenteritis may not have sought health care or had specimens submitted for testing (Bangura, 2002).

Other Vector-borne Diarrheal Diseases

Aeromonas, a genus of bacteria, occurs in soil and surface water and, as a result, people can be infected through food and water. They include diseases caused by parasites such as *Cryptosporidium* or by bacteria such as *Shigella* and *Salmonella*. The causative organism results in about 200 sporadic cases of gastroenteritis each year in the province (Bangura, 2002).

6.5.2 - Water Pollution

Water pollution not only endangers people but also wild plants and animals and domestic livestock. Some pollution originates from specific localized sources (point source pollution). In Saskatchewan most historic point sources of water pollution have been cleaned up and are carefully monitored to prevent future problems. On occasion, in the event of a large flood, some pollutants may escape into local watercourses. This can trigger toxic poisoning or more subtle problems, such as a reduction in the amount of oxygen in the water, causing die-offs of fish and other aquatic organisms. Pollutants such as dioxins and pharmaceuticals come from domestic sewage and can cause deformities in aquatic life and in amphibious species (such as frogs), muskrats and waterfowl.



In Saskatchewan, much water pollution comes from the general environment (non-point source pollution). Pollutants that reach watercourses from the general landscape are an insidious problem. These chemicals often act as fertilizers, increasing the growth of algae, including blue-green algae, in the water. Domestic livestock are often sickened and killed when exposed to the toxins given off by blue-green algae in dugouts and stagnant contaminated ponds. Eutrophication, where aquatic plants and algae grow profusely as a result of fertilizers, also depletes waterbodies of oxygen. These conditions of very low oxygen content result in suffocation of most aquatic animals.

Chlorine is used to treat domestic water containing high organic matter concentrations. An increasing concern is that if the organic matter concentrations become too high, the resulting by-products of heavy chlorine treatment are known to be carcinogenic. Furthermore, toxic wastes entering water treatment plants from industry or domestic wastes can reduce the effectiveness of the treatment plant to clean and purify the wastewater.

6.6 - KEY MANAGEMENT ACTIVITIES AND PROGRAMS

6.6.1 - New Legislation and Standards

The Environmental Management and Protection Act was amended in 2002 to expand compliance and enforcement for drinking water and wastewater management.

In December 2002, *The Water Pollution Control and Waterworks Regulations* were amended to become *The Water Regulations (2002)*. This revised regulation incorporates the recommendations of the North Battleford Water Inquiry, as well as elements of Saskatchewan Environment's long-term strategy on drinking water. Improved water management initiatives were developed since the drinking water related tragedy in the summer of 2000 at Walkerton, Ontario.

The Saskatchewan Water Corporation Act and *The Saskatchewan Watershed Authority Act* were proclaimed on October 1, 2002, to implement the government's water program reorganization.

6.6.2 - Changes to Water Management

The Saskatchewan government has reorganized water management responsibilities within government to clarify and streamline the roles of relevant agencies in this sector, partially in response to recommendations from the North Battleford Water Inquiry.

SaskWater

SaskWater has been re-focused as a Treasury Board Crown Corporation to provide solutions for rural and urban communities with water-related problems. SaskWater's regulatory program for municipalities has been transferred to Saskatchewan Environment.

Saskatchewan Environment

Saskatchewan Environment now has a more complete regulatory role covering both the construction and operation of water and wastewater works. In July 2002, Saskatchewan Environment established a new Drinking Water Quality Section to manage monitoring and compliance with drinking water and wastewater legislation and enforcement. During 2002-03, Saskatchewan Environment developed a new waterworks inspection protocol, a revised bacteriological follow-up protocol and several new guidelines for the design, management and operation of waterworks and sewage works. Saskatchewan Environment also developed a training protocol for staff inspecting waterworks. All inspection staff have received training in waterworks inspection and enforcement as of December 20, 2002. Multiple exams must be written to gain certification. During the 2001-02 fiscal year, approximately 550 waterworks inspections were conducted.

Saskatchewan Watershed Authority

A new Crown corporation, the Saskatchewan Watershed Authority, which reports to the deputy minister of Saskatchewan Environment, has the mandate to manage, administer, develop, control and protect the water, watersheds and related land resources of Saskatchewan. The Saskatchewan Watershed Authority is developing new approaches to address water use and protection concerns through watershed and aquifer planning that focuses on the creation of stakeholder or stewardship groups. In this manner, water resource and related ecological interests are both represented. A technical advisory team assists each planning effort. The desired outcome will be a locally endorsed management plan for a particular watershed or aquifer.

6.6.3 - Rural Water Quality Advisory Program

The Rural Water Quality Advisory Program is designed to address water quality problems encountered by rural residents who rely on their own private water source for residential and other domestic purposes. A trained technician samples raw water at source and advises the client on ways to improve or protect the quality of the water supply and correct any problems in the distribution system. Water samples are comprehensively analyzed at an accredited analytical laboratory. The Saskatchewan Watershed Authority also provides extensive consultation to its clients to provide advice on the best treatment methods and equipment to deal with identified water quality problems.

Since its inception in 1997, the Rural Water Quality Program has serviced over 2,100 rural households involving about 10,000 persons. The number of clients served annually is steadily increasing. Besides improving the aesthetics of water in the vast majority of cases, the program has identified and offered solutions to health-threatening situations which otherwise may have gone undiscovered. In addition, the water chemistry data collected is providing valuable information to government as an effective aid to water resource monitoring and management.

6.6.4 - Monitoring of Communicable Diseases

Saskatchewan Health and local health districts conduct surveillance of reportable communicable diseases, including the major enteric illnesses caused by *Campylobacter*, *Cryptosporidium*, *Cyclospora*, *Salmonella*, *Shigella* and the verotoxin *E.coli*. Epidemiological information on possible sources of the infection is analyzed at the health district to detect possible clusters and outbreaks in local jurisdictions. At the departmental level, data are analyzed on a broader basis to determine if there is a possible cross-jurisdictional or province-wide rise in occurrence of disease.

Currently, information about routine testing on the usual source of drinking water and test results is collected from all cases of a reportable enteric disease.

Saskatchewan Health has commenced the development of an integrated provincial water quality database that will enable health officials to link water quality data with epidemiological data. Along with this enhancement to waterborne illness surveillance, it will also allow for research into water-related health indicators.

6.6.5 - Regulation of Intensive Livestock Operations

Saskatchewan Agriculture, Food and Rural Revitalization provides technical support to intensive livestock operation (ILO) applicants for facility design, nuisance and pollution control, waste management and public process. Saskatchewan Agriculture, Food and Rural Revitalization and other government and non-government agencies extensively review proposed ILO projects to determine the adequacy and potential risk of all proposed manure storage structures, runoff control works and holding ponds, and the proposed manure management and dead stock management plans. For large operations, notice of the application is advertised in the local community and comments from the public are invited. Over 2,250 approvals for intensive hog, cattle and poultry operations have been issued since the regulatory program began in 1971.

The average size of ILOs is continually increasing, but Saskatchewan has many advantages in the development of ILOs and has not experienced the level of environmental concerns found in other jurisdictions. Legislation, in place since 1971, has regulated most ILO developments. Saskatchewan, Manitoba and Alberta have been working towards developing more consistent requirements for manure storage and management practices.

6.6.6 - Mine Waste Storage and Reclamation

Depending on the type and location of mines, different techniques are used to manage tailings, the residual materials of the mining process. No matter what style of tailings management facility is used, there is always a certain amount of risk that contaminants in the mine tailings could escape the confines of the facility. Every tailings management facility in Saskatchewan is extensively monitored to protect against such events. The in-pit facilities, which involve the highest level of engineering, are believed to provide the highest level of containment.

Once the ore of a mine has been exhausted, the mine and all of its facilities, including the tailings management facility, must be decommissioned and reclaimed to a condition that is as close to its original state as possible. This process must consolidate and cover tailings facilities and other potentially hazardous materials to prevent decommissioned mine sites from becoming a source of contaminants, such as heavy metals, radionuclides and, in some cases, acid mine drainage. All of these contaminants could potentially result in significant contamination of local water supplies.

6.6.7 - Stewardship Programs

Although legislative powers and measures are needed to set standards and to hold people accountable, regulations are not enough. Stewardship activities in the province encompass a variety of land and water use activities and are increasingly seen as an integral component of watershed management in the province.

The creation of stakeholder groups involved in the protection of watersheds and aquifers has been given added support and credibility in the province with the formation of the Saskatchewan Wetlands Authority. Established stewardship initiatives are continuing for lakes (e.g., Big Shell, Jackfish/Murray, Good Spirit), streams (e.g., Swift Current Creek, South Saskatchewan River), watersheds (e.g., Prairie Water Care 15 volunteer groups, Upper Assiniboine, Three Creeks), prairies (e.g., Blue Grama Grassland, Frenchman/Milk River Forage, Meacham Hills, Swift Current Forage) and aquifers (e.g., Regina, Yorkton). Stakeholder groups have recently been created for the Moose Jaw River, Last Mountain Lake, Upper Qu'Appelle River, Moosomin Lake, Long Creek, Crystal Lake, Cumberland Lake and Burntout Creek watersheds and Maple Creek aquifer.

7

BIODIVERSITY

CHAPTER OVERVIEW

Key activities or events affecting biodiversity: agriculture, forestry, watershed alterations and structures, road networks, fire suppression, exotic species, harvesting of resources, pollution, climate change. General impacts or effects: habitat loss, habitat fragmentation, degraded or compromised ecosystems, species loss.

Selected indicators or measures of the state of biodiversity: big game populations, game bird populations, commercial fishing harvests, sport fishing harvests, forest harvesting, species at risk, exotic species, habitat change, habitat protected.

Potential risks to ecosystem and human health: ecosystem change, contamination of waterbodies, pharmaceuticals and their effects on native plants and animals, chronic wasting disease, West Nile virus, Lyme disease, hantavirus, genetically modified organisms.

Key management activities and programs: Saskatchewan's Biodiversity Action Plan, Representative Areas Network, the National Accord for the Protection of Species at Risk, federal *Species at Risk Act*, federal Habitat Stewardship Program, habitat monitoring on the Canadian prairies, ecosystem-based management approach, Conservation Data Centre, Forest Management Effects Monitoring Program, Saskatchewan pasture programs, fisheries management, species recovery programs, index of ecological integrity.

General Observations and Trends:
Biodiversity in Saskatchewan has been greatly reduced and modified over the past century. The rapid breaking of native prairie for production of food grains and livestock has slowed, but new dangers to biodiversity face decision-makers.

Biodiversity continues to be compromised significantly by modern farming practices, forest harvesting, forest clearing for agriculture, alteration of waterways, fire management, exotic species, over-harvesting of some resources, pollution and, perhaps the greatest spectre of all, climate change.

By and large, natural resources such as fish, wildlife, harvestable tree stands and agricultural soils that are carefully managed are considered to have stable and viable populations and harvests are holding up accordingly. However, indications are that many populations of non-commercial species of wild plants and animals are in rapid decline.

Although over-harvesting likely caused the demise of many species in the early European settlement days, habitat problems are now the limiting factor of greatest concern. Native prairie habitat is now considered an ecosystem at risk. The rate of clearing and breaking of lands for agriculture in the boreal forest fringe, in the past couple of decades, has been three times as great as the world average. Proliferation of exotic species of both plants and animals is jeopardizing native species diversity.

The integrity of Saskatchewan ecosystems and human health may face serious long term risk from climate change if it disrupts terrestrial habitats and animal populations, speeds up eutrophication of waterbodies or creates conditions favourable to new pathogens and diseases.

The province is addressing the continuing loss of biodiversity through a number of strategies and programs, including a Biodiversity Action Plan, the Representative Areas Network and the Forest Management Effects Monitoring Program. There are also a number of co-operative programs between the province, the federal government and various non-government organizations, including implementation of provisions of federal and provincial species at risk legislation.

Work continues in determining suitable indicators for monitoring changes in the status of various components of biodiversity and ecological integrity.

7.1 - INTRODUCTION

The following chapter on biodiversity is organized similar to preceding chapters. It begins by providing information on activities or events that affect Saskatchewan's animal and plant species, or biodiversity. This is followed by information used to assess the health of biodiversity, the potential risks to ecosystem and human health, and descriptions of activities and programs that are underway to address the current threats to biodiversity.

This chapter is not intended to provide an exhaustive description of the state of biodiversity in Saskatchewan, but rather presents key information that is currently available. Much work has yet to be done on developing indicators to monitor the health of species' populations. Initiatives to address biodiversity threats are ongoing and part of a long-term process. This report is based on the best available information at the time of print.

7.2 - GENERAL DESCRIPTION

The term biodiversity (short for biological diversity) refers to the variety of all life and living systems on Earth, and includes the diversity of ecosystems, species and genes within the environment and their interactive ecological processes and functions. Saskatchewan has a rich diversity of habitats ranging from the arid prairies of the southwest through the aspen parklands and boreal forest in central Saskatchewan to the taiga in the far north. Occupying these different habitats are 414 species of birds, 79 species of mammals, 71 species of fish and close to 2,000 native plant species. In addition, the countless invertebrates, including insects, spiders, crustaceans and mollusks, not to mention microbes such as fungi, yeasts, bacteria and viruses, all play an interconnecting part in maintaining biological functions and processes.

With European settlement and increased human activities, the natural biodiversity of Saskatchewan has been seriously threatened. Large areas of habitat have been destroyed or altered and species such as bison, grizzly bears and Eskimo curlew were lost or displaced, often through over-harvesting. Today, approximately half of Canada's identified endangered and threatened birds and mammals are prairie species. Although little is known about diversity of invertebrates, initial studies indicate that many native insects are now rare and the list of invading exotic insect pest species continues to grow.

7.3 - KEY ACTIVITIES OR EVENTS AFFECTING BIODIVERSITY

The following section discusses some of the key human activities that are affecting biodiversity in the province and describes how these activities result in stress to these resources.

7.3.1 - Agriculture

Over 75 per cent of southern Saskatchewan has been converted to agricultural production because of ideal climatic and soil conditions. Where soils were suitable, habitats that were originally grassland and parkland have been lost through the clearing, breaking and sowing of land for agricultural purposes. Much of this conversion took place early in the 20th century. The reduction in habitat diversity, including drainage of wetlands, elimination of old farmsteads and fence lines and completion of agricultural field activities earlier in the growing season, have placed species at risk that had survived the original conversion of the native prairie habitat. These species include burrowing owl, long-billed curlew, swift fox, pintail duck, hog-nosed snake, sage grouse, Sprague's pipit and many species of native prairie plants.

On agricultural lands, the monoculture of annual crops is characteristically low in diversity, while permanent hay and pasture cover support a greater variety of species and genetic diversity. In the past decade, an increased use of zero tillage, a greater variety of crops, and more acreage under permanent cover have enhanced biodiversity to a limited degree (McClinton, 2002).

From the late 1960s to the mid-1980s, an aggressive program of wetland drainage and channelization for flood control resulted in serious loss of biodiversity associated with aquatic and riparian habitats. The loss of the wetland vegetation and associated animal life, including micro-organisms that provide a water filtering function, has coincided with water quality problems and population declines of many grassland and water birds.

The conversion of forested land to agricultural land also threatens the habitat of forest species, particularly in the Aspen Parkland and Boreal Transition ecoregions. Only an estimated 22 per cent of the forest remains in the fringe area of these ecoregions. Species such as migratory neotropical song birds are deprived of habitat as a consequence (Thorpe and Godwin, 1999).

Heavy grazing by domestic livestock can alter grassland habitat. Properly managed grazing can benefit grasslands and biodiversity by promoting a greater diversity of native grasses. Heavy grazing reduces the taller grasses and eliminates the more palatable species and, hence, overall biodiversity. Heavy browsing on sagebrush and other wildlife food shrubs leaves the plants stunted and unproductive. This loss of food is believed to be a threat, in particular, to sage grouse, pronghorn antelope and other prairie browsers. Heavy grazing in riparian areas can destroy much of the vegetation that provides critical habitat for many wild species. A survey of 600 sites in areas affected by agriculture in Saskatchewan found that approximately 60 per cent of the length of creeks had grazing along the shorelines and, of this, 20 per cent had heavy or extreme grazing (Thorpe and Godwin, 1999).

Because so much of southern Saskatchewan is devoted to the production of agricultural crops, there is also a danger to biodiversity from agricultural pesticides and fertilizers. Some pesticides have been implicated in the poisoning of wildlife, destruction of rare plants and contamination of water supplies. Poorly managed use of fertilizers and concentrated application of animal manure potentially pollute aquatic ecosystems and poison beneficial soil micro-organisms. In addition, targeted agricultural pests can genetically develop a resistance to chemicals over time, necessitating the use of new and potentially more harmful chemicals. Pesticides that are non-target specific will kill a broad spectrum of organisms including beneficial native plants, insects and birds.

A relatively new agricultural commodity, wild rice production in northern lakes, converts an ecosystem of several aquatic species to one crop within a relatively pristine landscape. The diversity of plant life in these waterbodies is greatly reduced. In addition, the large amount of seed produced acts as an attraction to waterfowl, muskrats and other seedeaters. These species become pests to the wild rice producers and are often killed off as part of pest control.

Regulatory mechanisms usually control transmission of diseases between domestic animals and wild species. However, history has shown that exchange of disease between wild and tame stocks has occasionally occurred, causing ecological damage and great expense to society when trying to control the disease problem. In addition, escape of game or fish-farmed animals such as wild boar and carp has created serious ecological damage. Once established in the wild, many of these species are virtually impossible or very expensive to control.

7.3.2 - Forestry

Even though it is known as a prairie province, Saskatchewan is actually more than 50 per cent forested. Tree species of commercial importance for timber or fibre are white spruce, jack pine, black spruce, trembling aspen and balsam poplar. White birch, tamarack and lodgepole pine are also harvested for specialized products and firewood. Only the southern portion of the provincial forest, the area lying between the Churchill River and the agricultural lands to the south, is currently classified as the Commercial Forest Zone, containing forests viable for sustainable timber harvesting activity. There are about 12.2 million hectares of commercial forest, of which 97 per cent is on Crown lands.

In central Saskatchewan, where forestry is the major land use, biodiversity can be affected by logging and silvicultural practices. A major concern associated with clear-cutting is land that is not sufficiently restocked (NSR). Not sufficiently restocked land is a commercial forestry term that refers to productive forestland that has not met its potential to support tree growth in order to produce a commercially attractive stand of mature trees. Harvested and NSR lands are often characterized by excessive soil disturbance, a loss of nutrients due to timber removal, and compaction. Compacted soils are not able to support tree establishment or normal tree growth rates. Harvested areas that fail to regenerate adequately, significantly change the species composition and reduce the variability of the plants and animals living there. Planted stands are also much more susceptible to disease or insect epidemics and they may lack the genetic diversity needed to balance and buffer a natural ecosystem against large-scale or rapid change (Draper, 1998).

Forest harvesting and fire management depend on roads and trails to provide access. These roads not only remove forested habitat, but also expose formerly remote areas that have unique ecological characteristics and diversity to disruption by humans and intrusions by exotic species. New roads and trails also provide new travel lanes that may upset predator-parasite-prey relationships.

The over-harvesting of mature trees can remove all trees of a certain species or physical characteristic, eliminating or reducing wildlife species that directly or indirectly depend on them. For example, harvesting of large old trees eliminates northern oriole and pileated woodpecker nesting habitat. The loss of shade provided by these few old trees may raise the summer water temperatures in the stream to the detriment of cold-water fish and invertebrates.

7.3.3 - Watershed Alterations and Structures

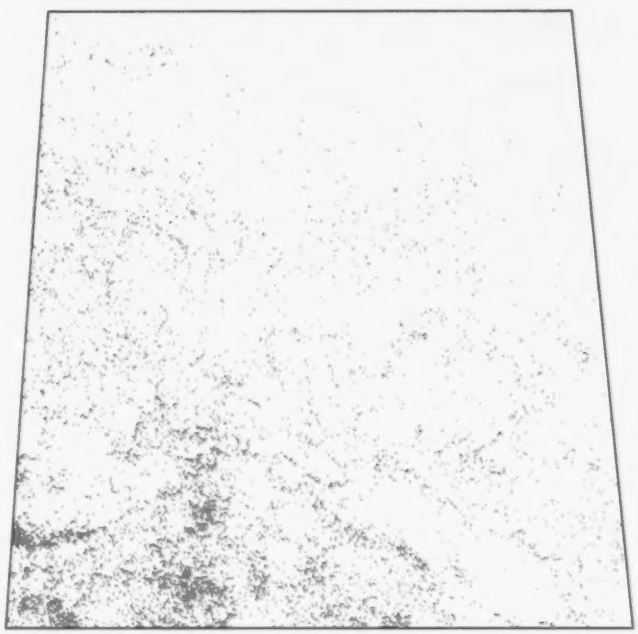
Dams and control structures in Saskatchewan have had significant effects on biodiversity in aquatic ecosystems. Dams on rivers and streams essentially change a river or stream environment to a lake environment. Many native plant and animal species disappear, while other exotics may replace them. Dams alter water flow, fragment habitat, block migration routes of aquatic species and flood essential spawning habitat for many fish. The loss of larval fish through entrapment at power plant intakes or spillways can jeopardize whole fish populations.

Dams, which prevent annual flooding downstream, deprive riparian vegetation of needed moisture and nutrients. For example, riparian cottonwoods are not regenerating on most prairie rivers that have been dammed because they require flood-deposited silt. The elimination of spring flooding of the Cumberland Delta by the E.B. Campbell Dam is resulting in a loss of young willows, which are a principle food for moose. The loss of willow has coincided with a major decline of moose populations. These and other ecological problems associated with the changed water regimes below the dam have contributed to hardship for the hunting and trapping communities around Cumberland House (NCFDC, 2002).

Within the reservoir, changes in the timing of water level fluctuations pose problems to lake-spawning fish and shoreline-nesting birds, such as piping plover, because the water levels are either too high or too low at critical times in the animal's life cycle. Fluctuating and high water levels in reservoirs accelerate shoreline erosion, which creates banks that are used by animals for nests and dens. However, the banks are often unstable and may collapse and trap species such as nesting prairie falcons, golden eagles, bank swallows, rock wrens and belted kingfishers. Sudden changes of water levels below dams can drown unsuspecting slow-moving species or can trap fish in shallow, de-watered areas of reservoirs.

Streams and rivers are fragmented by water control structures, of which there are over 8,400 in southern Saskatchewan alone. As a result of these, and numerous channelization projects, the flow regimes of many streams are significantly altered, both in terms of their magnitude and timing of flows. This hinders the movement of aquatic species and seriously jeopardizes their reproduction or subjects them to strandings or other physical misfortunes. See Figure 7.1 for registered water control structures in Saskatchewan.

Figure 7.1 Registered Water Control Structures in Saskatchewan



Data Source: SaskWater

Wetlands have often been referred to as the kidneys of the prairies because they filter out pollutants contained in runoff and act as a sponge to slow down the movement of water through the watershed. Drainage of wetlands reduces the filtering and purification of water in the ecosystem, reduces habitat and negatively impacts wildlife. It is estimated that Saskatchewan has lost about 40 per cent of its wetlands over the past several decades.

The channelization of rivers, such as the Qu'Appelle River, has also greatly reduced natural biodiversity because the natural meanders that consist of a multitude of small habitat niches are replaced by a straight ditch. Various natural aquatic and riparian vegetation communities are changed to a few weedy species, and the silt load of the running water is greatly increased to the detriment of most aquatic organisms.

Channelization reduces the amount of flooding to intensively managed lands, but destroys the natural regime of flooding essential to the survival of many plant and animal species. Channelization changes the physical diversity of a waterway, including water velocity, substrate conditions, pools, riffles, meanders and floodplains. This can lead to increased erosion and reduced sunlight in the water, which affects all aquatic organisms. Removal of bank and riparian vegetation increases water temperatures and reduces the diversity of aquatic plants and animals.

7.3.4 - Road Networks

Saskatchewan has about one-third of all the roads in Canada, with a road or a road allowance at least every 1.6 km throughout the surveyed part of the province.

Roads change the movements of certain animals, threaten populations through vehicle collisions and affect waterways. The proliferation of roads also allows for easier access to remote areas by hunters and non-human predators. Each road creates a break in the pattern of the natural plant and animal community so that the overall carrying capacity for any one species may be affected. Roads to mines and forest harvest areas also fragment the landscape. Roads increase erosion of land and siltation in waterways as well, thereby impairing aquatic habitat.

7.3.5 - Fire Suppression

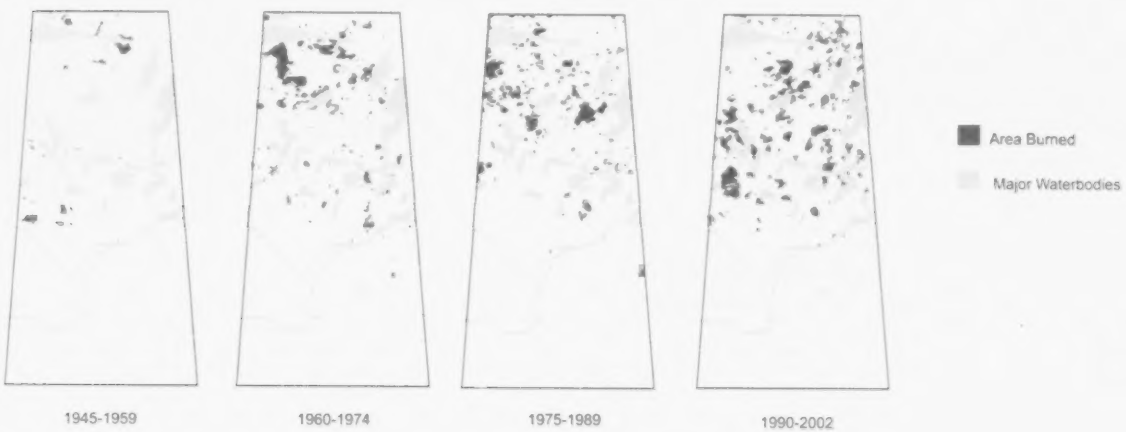
Wildfires historically shaped the natural landscape of Saskatchewan, but they have been largely eliminated in agricultural areas, changing the disturbance regimes on native portions of the landscape. Native grasslands and slough edges now have larger amounts of shrub and tree cover, habitat preferred by species such as white-tailed deer. However, critical non-treed, grassy habitat for species such as burrowing owl, Sprague's pipit and swift fox has been much altered. The sharp-tailed grouse, Saskatchewan's bird emblem, uses shrubby habitats for cover but requires open grassland for much of the rest of its activities.

Suppression of wildfire has also contributed to the loss of the fescue grassland component of the Aspen Parkland Ecoregion, an area of tree bluffs interspersed with grassland dominated by rough fescue grass *(Festuca hallii)*. With the suppression of fires, woody native species tend to take over grasslands. The fescue grassland ecosystem is one of the most threatened on the prairies.

Fires are part of a natural rejuvenation process in the forest, helping to create a mosaic of different age groups of forest vegetation. Numerous unburned patches provide habitat for species such as mosses, fungi, lichens, large trees, orchids, red squirrels, winter wrens and woodland caribou. Burned areas allow for new vegetation to grow and animals such as beaver, moose and deer to benefit from the highly nutritious regeneration. This diversity of landscape results in greater diversity of wildlife. Also, many forest plant species require fire to release and germinate seeds. Jack pine and black spruce benefit from the heat of a good burn to open their cones.

Because of active forest fire suppression over the past 50 years in Saskatchewan, the average age of the southern boreal forest is increasing. Fuel loads are higher in older forest stands. Consequently, the suppression of fires in the southern portion of the provincial forest is creating fuel conditions that favor larger, hotter fires. This is a key threat to human property, livelihoods and biodiversity. See Figure 7.2 for a fire history in Saskatchewan from 1945 - 2002.

Figure 7.2 Fire History in Saskatchewan, 1945-2002



Footnotes: Fire data has not been included for the following years: 1951, 1954, 1962, 1965.
Fires that occurred after August 22, 2002 have also not been included.
Data Source: Saskatchewan Environment.

7.3.6 - Exotic Species

Exotic species are usually introduced by humans, either accidentally or purposely, into ecosystems that have not evolved along with these species. The impacts of invasive exotic species are often very extensive and difficult to mitigate. The delicate balance between different species and habitats is upset and the diversity of life that has developed over thousands of years is permanently and rapidly reduced or changed.

Genetically modified organisms (GMOs) can also be considered exotic species. Because the science of genetic engineering is new, there are many unknowns about how GMOs interact with the natural environment over the long term. To date, few studies have been done to develop a clear understanding of these ecological risks. For example, there is controversy over the potential impact of GMOs, which may have a similar or even more extensive impact than other exotic species. Humans have conducted selective breeding for thousands of years with little impact on the environment. However, selective breeding, or the development of hybrids, is usually between the same species of organisms to, for example, develop different corn varieties or cattle breeds. Modern science can now combine genetic material from completely different organisms such as corn and wheat or, perhaps even corn, pigs and bacteria. The change may be too sudden for an ecosystem that has gradually evolved over many millennia of generations.

7.3.7 - Harvesting of Resources

Hunting has always been an important activity in Saskatchewan. In the early days of the fur trade and European settlement, over-hunting was the norm rather than the exception, resulting in widespread decimation of many game species and predators. By depleting a particular species, other species in the same ecosystem are inadvertently affected. The removal of wild bison from the prairies eliminated the major prey for the wolf and plains grizzly, which led to their own decimation. With the elimination of these major predators, coyotes, red foxes and other smaller predators have grown in numbers.

For the past century, hunting has been intensively managed to control over-harvesting and to maintain all species at population levels that are acceptable to society. The practice of game management follows the principles of sustained yield in that harvests only remove surplus animals that would die ordinarily from natural causes. As a result, hunting seasons are based on accurate estimations of wildlife populations and are restricted when population levels cannot sustain additional mortality.

For the most part, harvesting of fish in Saskatchewan is also extensively regulated. Game and commercial fish in northern Saskatchewan lakes are subjected to harvests by sport and commercial fishers, and to domestic fishing by First Nations people. Harvest quotas regulate commercial fishing for each lake. Sport fishing is managed on a regional or watershed basis, through regulations limiting the size of the catch, size of the fish and catch-and-release regulations. Domestic fishing is largely unregulated as long as the fish are used for local consumption. If large predators such as game fish are over-harvested, food or forage species such as suckers increase. These species in turn eat the eggs of the game fish. The total fishery may suffer as a result.

Trapping was the industry that initially brought Europeans to Saskatchewan. At various times over the past 300 years, over-trapping has periodically reduced fur-bearing animals to virtual extirpation, forcing First Nations peoples and European fur traders to move away. With European settlement of the province, wild furbearers were often over-harvested, once again to the extent that the restocking of beaver was a major program for the Department of Natural Resources in the 1940s. Since the Northern Fur Program was implemented in 1946, fur trapping in Saskatchewan has been closely managed, and animals are now trapped using the most humane methods possible.

Trapping is no longer a major industry but does substantially supplement the incomes of northern residents and rural people in southern Saskatchewan. The size and value of provincial fur harvests reflect prices and relative abundance of the animals. At the time of writing, fur prices are undergoing resurgence as new markets open up in East Asia and Europe.

7.3.8 - Pollution

Numerous toxins are released into the environment by Saskatchewan's industries, communities and households. These are regulated to generally acceptable levels, but accidental releases or localized impacts may occur. These are regulated to generally acceptable levels but accidental releases or localized impacts may occur. Oil, gas and brine spills occur through the extraction of oil and gas and can destroy small areas of native vegetation or contaminate aquatic habitats. In the mining industry, salt emissions from potash mines have been known to damage aspen bluffs close to the mine. Radioactive by-products of the uranium mining industry in northern Saskatchewan can contaminate lakes and groundwater. Pulp mills can release toxic chemicals such as dioxins and furans. Acid precipitation drifting in from industrial development in Alberta could also pose a threat to terrestrial vegetation and aquatic life in the future, but as of yet, no significant damage in Saskatchewan has been noted.

7.3.9 - Climate Change

Global warming is expected to alter habitats and ecosystems. Natural variability has given our native ecosystems resilience and diversity, but rapid climate change is expected to affect all ecological processes, habitats and biodiversity. Many organisms will attempt to disperse or migrate as habitats change, but some may not be able to because suitable habitat is too far away or no longer exists. While some animal and plant populations will diminish, other organisms such as insect pest populations and diseases carried by insects will flourish as a result of warmer winters, dry springs or other weather anomalies. This could lead to greater incidences of disease in agricultural food crops, native prairies, forests and in animal (including human) populations. The frequency of forest fires may also increase, resulting in an ever-decreasing ability of many forest ecosystems to rejuvenate to a fully stocked stand of mature trees and accompanying organisms.

Other plant and animal species may be forced out of protected areas, particularly in the southern half of the province, where they could be more vulnerable because of extensive habitat loss and fragmentation. Of particular concern is the Cypress Upland Ecoregion. This very diverse and unique ecosystem could be lost and replaced with something much different than the lodgepole pine, orchids and other rare plant and animal communities presently found there.

7.4 - SELECTED INDICATORS OR MEASURES OF THE STATE OF BIODIVERSITY

Harvest trends are monitored to determine how human exploitation is affecting the ability of wildlife to maintain itself. Harvest totals and harvest rates are used in game management as an index to population status. By monitoring trends in harvests, the sex and age ratio of harvested animals and the hunting effort required to harvest an animal, biologists can deduce whether a healthy population of a given species is being sustained.

The population trends of wildlife species that are neither hunted nor trapped are generally poorly documented. For example, before the 1980s, information about songbirds was sometimes recorded by individual naturalists in very local areas. These very spotty efforts at monitoring are limited in their usefulness. More concentrated efforts in the past 20 years by non-game biologists and naturalists are now providing useful status reports about rare plants, migratory birds, reptiles and amphibians. Special efforts have been directed at species at risk. Population status of other animals such as non-pest insects, spiders and crustaceans is limited to inventories of suitable habitat where habitat relationships are understood.

7.4.1 - Big Game Populations

Recorded harvests of game animals is a useful measure of trends in relative population numbers of animals that are hunted, fished and trapped.

For the past 20 years, overall provincial big game harvests have remained relatively high. In 2001, approximately 49,069 big game animals were harvested, compared to 50,420 in 1981 (SERM, 1982; Arsenault, 2002). The most hunted big game species in Saskatchewan, including white-tailed deer, mule deer, moose and black bear, have had generally stable populations over the past decade. See Table 7.1 for big game harvests.

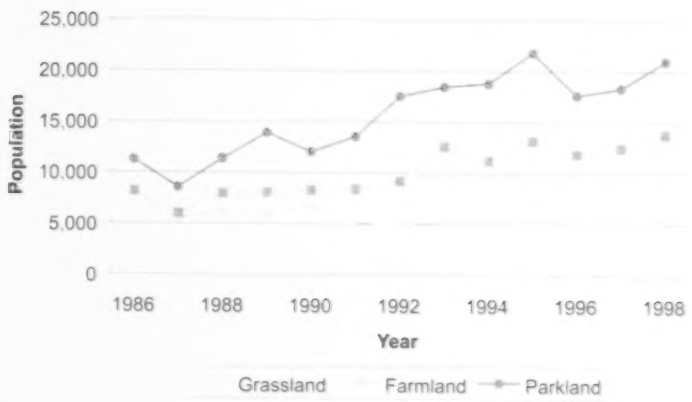
Table 7.1 Big Game Harvests

Year	White-tailed Deer	Moose	Mule Deer	Antelope	Black Elk	Bear	Caribou	Total
1981	41,149	2,247	3,662	1,856	523	929	54	50,420
1986	34,742	3,566	9,650	2,534	868	2,391	91	53,842
1991	38,025	4,246	16,648	7,620	1,665	1,224	87	69,515
1996	46,750	3,369	6,917	1,678	1,732	2,437	44	62,927
2001	34,132	4,177	6,264	N/A	2,270	2,226	N/A	49,069

Source: SERM, 1982, 1987, 1992, 1997; Arsenault, 2002.

White-tailed deer are found throughout Saskatchewan but at greater densities in some ecoregions and local areas. See Figure 7.3 for harvest of white-tailed deer in southern Saskatchewan from 1986-1998.

Figure 7.3 Southern Saskatchewan Resident White-tailed Deer Harvest, 1986-1998

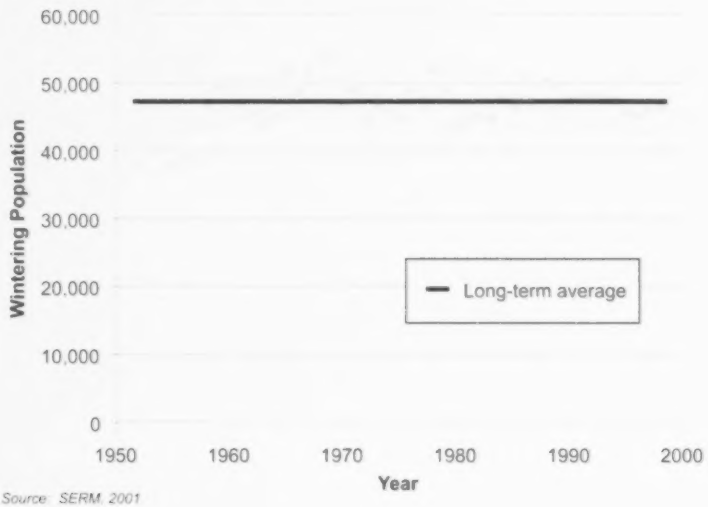


Footnote: Does not include the harvest of white-tailed deer in forested areas.
Source: SERM, 2001.

Mule deer have gradually expanded their range eastward in the past 30 years to re-occupy habitat from which they were extirpated in the first half of the 20th century. In the core area of their distribution in southwestern Saskatchewan, mule deer reached super-abundance in the late 1980s and early 1990s. Landowners experienced high levels of crop depredation from the deer and there was concern that the deer habitat was being over-utilized. Liberalized hunting seasons helped to reduce breeding populations to their presently moderate population levels.

Moose generally frequent the boreal forest and islands of forested habitat, such as Moose Mountain and Cypress Hills provincial parks. In recent years, moose have been occupying more and more areas of the aspen parkland as depopulation of humans in rural areas continues. In the boreal forest, forest harvesting and forest fires favor moose populations because food supplied by new growth in these areas is abundant. Figure 7.4 shows that the winter population of moose has been relatively stable over the past 50 years.

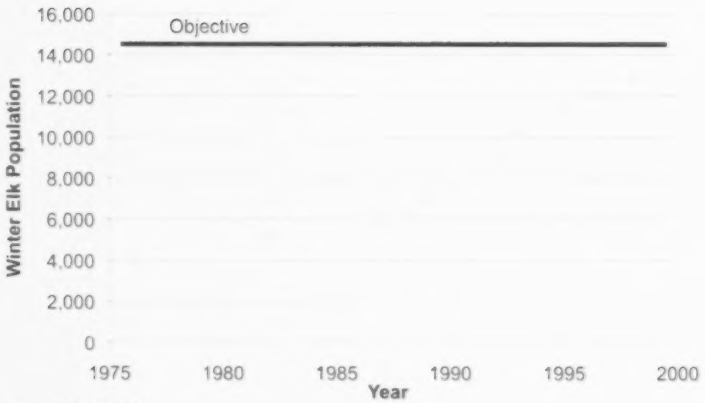
Figure 7.4 Changes in Winter Moose Population in Saskatchewan



Source: SERM, 2001

Elk populations have steadily increased from low populations in the early half of the 20th century and are now widely distributed along the forest transition zone and throughout suitable areas of aspen parkland and grasslands (Figure 7.5).

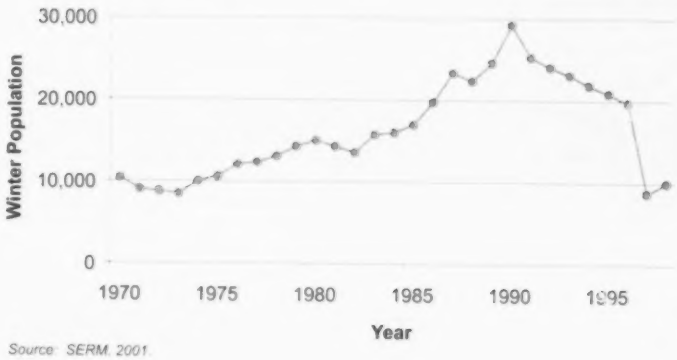
Figure 7.5 Provincial Winter Elk Population Estimate in Relation to Long-term Objectives



Source: SERM, 2001

Pronghorn antelope reproductive success has been low since the late 1980s and overall populations have been declining accordingly. Population studies have indicated that antelope females have been giving birth to normal numbers of young, but that the survival rate of the young has been much too low to sustain a higher population. Many other non-game species of the Prairie Ecozone have shown weak population growth in the past decade as well. The reasons for this ecological phenomenon are not clear. See Figure 7.6 for changes in pronghorn populations over the last 30 years.

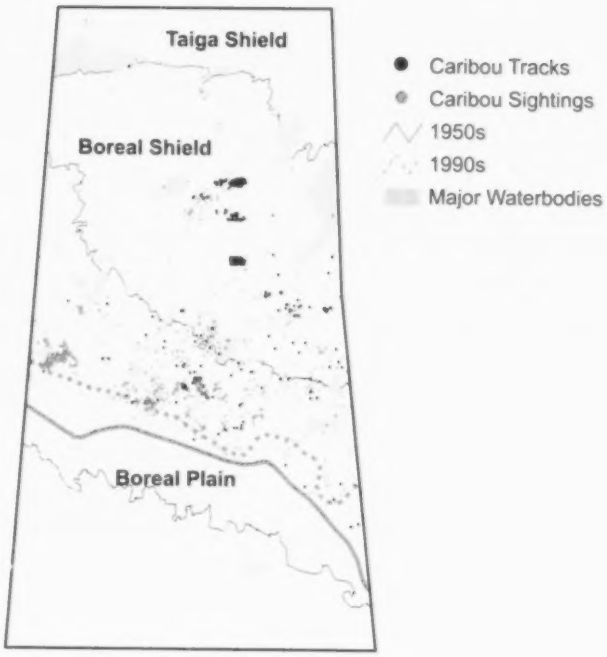
Figure 7.6 Changes in Pronghorn Populations in Saskatchewan, 1970 to Present



Source: SERM, 2001.

Woodland caribou populations have also declined over the past 30 years. This species requires large areas of undisturbed wilderness in the boreal forest to survive and has been extirpated from a number of small remnant habitats. Woodland caribou is now listed as a threatened species and is no longer hunted anywhere in western Canada. When hunting seasons are closed, valuable harvest data is lost, and the knowledge about species populations is compromised.

Figure 7.7 Woodland Caribou Range Contraction in Saskatchewan



Source: Wiltse and Arsenault, 2002.

7.4.2 - Game Bird Populations

Game bird populations can fluctuate greatly from year to year depending on successful reproduction. Prairie waterfowl populations are most significantly affected by drought cycles. Many ducks, for example, fly over dried-out nesting areas in the south to northern areas of inferior habitat or forego breeding and nesting altogether. Prairie duck populations have undergone a dramatic decline in recent years. Population estimates for ducks in southern Saskatchewan have been some of the lowest in 20 years. Figure 7.8 shows the population changes in pintails and scaup, which are in serious decline. Mallards, redhead, American widgeon, canvasback and teals have remained relatively stable or increased slightly. Gadwall and shoveler ducks have increased. These longer-term population fluctuations are likely caused by complex inter-related ecological factors that limit populations of some species and cause others to grow.

Figure 7.8 Pintail and Scaup Populations in Saskatchewan, 1954-2002

Footnote: Data are to the 95% confidence level in the traditional survey area for the North American Waterfowl Management Plan (NAWMP). The dashed line indicates the population goal.
Source: U.S. Fish and Wildlife Service, 2002.

Harvest levels for provincial game birds have varied over the past 20 years. In 1981, 240,000 ducks were harvested, while in 2001, 153,504 ducks were harvested. Geese and sandhill crane harvests have most significantly increased since 1981, while pheasant harvests have most significantly decreased from 12,500 in 1981 to 4,639 in 2001 (Table 7.2).

Table 7.2 Saskatchewan Game Bird Harvests

Year	Ducks	Geese	Sandhill Crane	Grouse (sharp-tailed, ruffed and spruce)	Hungarian Partridge	Pheasant	Total
1981	240,000	159,000	2,200	125,900	64,000	12,500	603,600
1986	181,077	159,111	7,480	138,426	92,270	10,557	588,921
1991	101,977	122,972	3,594	97,783	93,627	15,975	435,928
1996	190,133	220,287	2,961	107,391	42,289	13,873	576,934
2001	153,504	323,317	7,538	86,595	76,807	4,639	652,400

Footnote: It should be noted that most ducks, large Canada geese and upland birds harvested in Saskatchewan are raised in this province, but all other geese and sandhill cranes nest in the Arctic and are harvested as they pass through the province during migration.
Sources: SERM, 1982, 1987, 1992, 1997; Smith, 2002.

7.4.3 - Commercial Fishing Harvests

Commercial fishing harvests have been relatively consistent in the past six years, with much of the variability directly tied to markets and prices, particularly for whitefish and mullet (suckers). The prices, not the state of the resource, determine the level of harvest, although there are also separate species quotas to maintain sustainable harvests. The consistent production figures, by lake, from year to year, provide evidence that harvests and healthy fish populations are being maintained. Enhanced efforts by the Freshwater Fish Marketing Board to market underutilized species has resulted in reduced discarding of "bycatch" such as suckers and burbot. The commercial fishery provides a balance in the overall fish harvest by taking rough or strictly commercial species (e.g., whitefish and tulibee) to compensate for the angling harvest of sportfish.

Commercial fishing involves the harvesting of game fish species, bait fish and brine shrimp. Table 7.3 illustrates the harvest trends for each component of the commercial fishery. Largely because of the fluctuations of markets and prices, production of game and bait fish has dropped significantly in the past 15 years, while brine shrimp harvests have increased dramatically.

Table 7.3 Commercial Fishing Harvests

Year	Commercial Bait Fish Production (kg)	Commercial Brine Shrimp Production (kg)	Commercial Game Fishing Production (kg)*
1986-87	17,912	49,409	3,740,418
1991-92	12,947	31,517	4,095,183
1996-97	5,571	36,726	3,133,933
2000-01	7,639	166,161	3,274,487

*Footnote: *Includes whitefish, lake trout, walleye, northern pike, tullibee and others.*
Source: Kelly, 2002.

7.4.4 - Sport Fishing Harvests

In 2000, a Saskatchewan sport fishing survey indicated that anglers caught an estimated 11.4 million fish of all species and retained approximately 3.4 million of them, accounting for a harvest that weighed 2.5 million kilograms. The survey conducted did not estimate the harvest by children, who make up approximately 25 per cent of active anglers.

While direct revenues have increased for sport fishing (see Section 3.6.3), the amount of fish harvested has been declining. Anglers kept approximately 2.07 million fewer fish in 2000 than in 1980 (5.51 million compared to 3.44 million). The total weight of all fish caught declined from 4.97 million kilograms in 1980 to 2.56 million kilograms in 2000, a difference of 2.41 million kilograms. This could be the result of a larger percentage of fish being released. The majority of fish species caught were perch (30 per cent), walleye (26 per cent) and pike (23 per cent) (SPRR, 1981; SERM and Department of Fisheries and Oceans). See Table 7.4.

Table 7.4 Sport Fishing Harvests

Year	# of Fish Kept* (millions)	Fish Weight* (kg in millions)
1980	5.51	4.97
1985	4.77	4.23
1990	4.82	3.85
1995	3.87	2.90
2000	3.44	2.56

*Footnote: *Numbers do not include fish taken by anglers under the age of 16.*
Sources: SPRR, 1981; SPRC and Department of Fisheries and Oceans, 1986; SERM and Department of Fisheries and Oceans, 1991, 1996.
Data Source for 2000: Saskatchewan Environment and Department of Fisheries and Oceans.

Studies have shown that road access to lakes can cause fish populations to rapidly diminish. Walleye, for example, have been depleted in lakes such as Dore when road access provided opportunity for recreational fishing in addition to commercial fishing. Lake trout, as well, have been reduced in numbers in Lac La Ronge and appear to no longer exist in lakes such as Amisk, Pelican and Mirond. Lake sturgeon are also suspected to have declined in numbers due to over-harvesting and impediments, such as dams, to spawning habitat. Over-harvesting of fish species in a particular lake can significantly reduce numbers of breeding adults. Inbreeding results and genetic diversity is compromised, making populations more susceptible to disturbances.

7.4.5 - Forest Harvesting

On average, about 24,000 ha of provincial forest are harvested each year. Most of the harvested land is currently reforested by the planting of seedlings, but there is a backlog from previous years when this was not done. Table 7.5 provides information on the number of hectares of forested land harvested and the number reforested, from 1996-2000.

Table 7.5 Hectares of Saskatchewan Forest Harvest Activities for 1996-2000

Forest Activities	1996	1997	1998	1999	2000
Total Forest Land (million ha)	28.8	28.8	28.8	28.8	28.8
Commercial Forest Lands (million ha)	12.2	12.2	12.2	12.2	12.2
Total Forest Harvested/year	18,005	16,266	16,863	20,334	23,966
Reforestation/year	8,420	15,700	11,500	12,363	13,300
Backlog Harvested Lands Restocked	1,620	931	1,650	2,025	3,100

Source: Saskatchewan Environment.

According to *The State of Canada's Forests 2001-2002* (Canadian Forest Service, 2002), 64 per cent (269,000 ha) of harvested Crown land in Saskatchewan is considered not sufficiently restocked (NSR), or understocked. This is significantly higher than the percentage of harvested Crown land that is NSR in Canada, which is 12 per cent or 2.0 million hectares. Much of these lands are the result of previous Forest Management Agreements (FMAs) that did not ensure adequate replanting by the forestry companies. Although current FMAs require companies to adequately restock harvested lands, the success rate of replanted trees is not as high as natural regeneration following fire.

7.4.6 - Species at Risk

Many plants and animals native to Saskatchewan have suffered population reductions over the past 150 years. Some species that were unique to good agricultural soils have been largely eliminated, while others that depend on a combination of habitats have survived, albeit in much reduced numbers. As land use has intensified in more recent times, species least adapted to reduced landscape diversity have continued to decline. Many species inhabiting the Canadian prairies that have shown recent declines are now officially listed as "species at risk."

Saskatchewan Environment's Conservation Data Centre (CDC) plays a vital role in identifying species of concern in the province. Currently in Saskatchewan, there are more than 500 species that are provincially ranked at varying levels of risk. The majority of these species at risk are native plants occurring in the south. The CDC listing is the recognized indicator of the actual number of species at risk in the province. See Appendix 3: Conservation Data Centre's Species of Concern in Saskatchewan.

To facilitate the protection of species at risk, Saskatchewan amended *The Wildlife Act* in 1997 to allow the listing of species as endangered, threatened or vulnerable. As of 2002, 15 species have been listed and a further 32 have been recommended for listing. See Table 7.6 for these species.

Table 7.6 Saskatchewan Species at Risk Listed under The Wildlife Act

Common Name	Scientific Name	Status
Animal Species		
Black-footed ferret	*Mustela nigripes*	extirpated
Burrowing owl	*Athene cunicularia*	endangered
Eskimo curlew	*Numenius borealis*	extirpated
Greater prairie chicken	*Tympanuchus cupido*	extirpated
Grizzly Bear	*Ursus arctos horribilus*	extirpated
Piping plover	*Charadrius melodus*	endangered
Sage grouse	*Centrocercus urophasianus*	endangered
Swift fox	*Vulpes velox*	endangered
Whooping crane	*Grus Americana*	endangered
Plant Species		
Hairy prairie-clover	*Dalea villosa*	endangered
Sand verbena	*Abronia micrantha*	endangered
Slender mouse-ear cress	*Halimolobos virgata*	threatened
Tiny cryptanthe	*Cryptantha minima*	endangered
Small white lady's-slipper	*Cypripedium canadium*	extirpated
Western spiderwort	*Tradescantia occidentalis*	endangered

Source: Saskatchewan Environment

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) also conducts national assessments of species for protection under federal legislation. The provincially listed species differ to some degree from the COSEWIC list due to different priorities and regional concerns. See sidebars for stories on two endangered species, the swift fox and the burrowing owl.

The Return of the Swift Fox

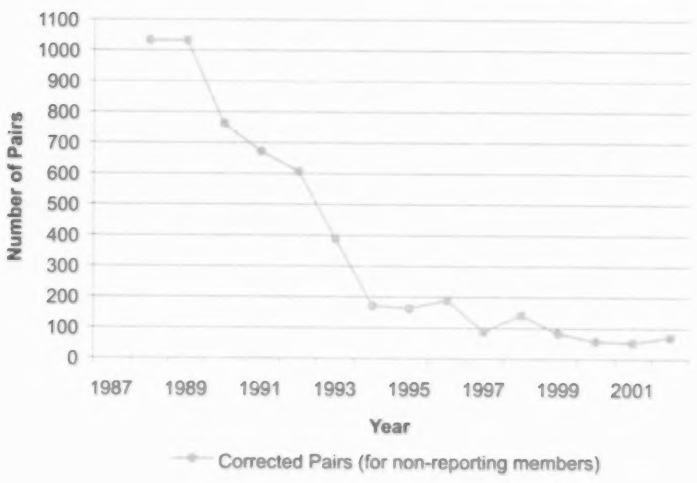
The swift fox (*Vulpes velox*) is a prairie conservation success story. This small cat-sized fox once scavenged food after prairie wolf kills on bison and other large mammals. After the bison were killed off and replaced by cattle and other domestic livestock, massive poisoning programs aimed at eliminating prairie wolves and coyotes eliminated the swift fox (as well as the prairie wolf). The swift fox was considered extirpated from Canada until 1983. A recovery plan prepared for the Committee on the Status of Endangered Wildlife in Canada recommended restocking animals from elsewhere into suitable prairie habitat in southwestern Saskatchewan and southeastern Alberta. A small group of private and government conservationists started releasing foxes over the course of several years. The stocked animals came from a captive breeding population in Alberta and from wild populations in the western United States. Now, a small breeding population of approximately 1,000 swift foxes has been established in Saskatchewan and Alberta. These animals all appear to be the result of successful reproduction in the wild.

Burrowing Owls, A Swift Decline

The burrowing owl, *Athene cunicularis*, has been classified as an endangered species since 1995 by the Committee on the Status of Endangered Wildlife in Canada and is protected under provincial and federal law from being disturbed, collected, harvested, captured, killed or exported, and their residences are protected from destruction in Saskatchewan. If current trends continue, this species will likely disappear entirely from Saskatchewan by 2010 (Houston et al., 1996; Skeel et al., 2001).

Habitat loss and fragmentation pose serious problems for burrowing owls. The owls nest in abandoned mammal burrows in the ground in open short-grass prairie or grazed pastures. By 2000, only 20 per cent of former grasslands in Saskatchewan remained as natural habitat, and in more intensely farmed areas, native grasslands have been reduced to less than 2 per cent of the landscape (Hammermeister et al., 2001). Habitat destruction on the owl migration routes and wintering grounds, pesticides and prey populations also contribute to low owl recruitment and high owl mortality. The Saskatchewan breeding population declined by 95 per cent between 1987 and 2002 (see the following figure), and its breeding range in Saskatchewan has shrunk southward and westward since the 1940s.

Operation Burrowing Owl (OBO) is a voluntary stewardship program that enlists the assistance of landowners to preserve critical habitat for the birds. In 2001, OBO protected 22,594 ha of burrowing owl habitat on private land and 38,920 ha of burrowing owl habitat on public land (Nature Saskatchewan, unpublished data). Population trends are shown in the following figure. In 2002, 66 owl pairs were recorded at 48 out of a possible 604 OBO sites, a 30 per cent increase over 2001, when 51 owl pairs were recorded. This is only the second recorded increase in owl numbers since OBO began in 1987. However, this slight increase in actual numbers of pairs seems insignificant compared to the major decline from over 1,000 pairs in the late 1980s.



Source: Nature Saskatchewan

7.4.7 - Exotic Species

In agricultural Saskatchewan, exotic species have contributed greatly to the decline of biodiversity. Many agricultural weeds not only reduce crop yields but also displace native species that are essential to performing natural processes and functions.

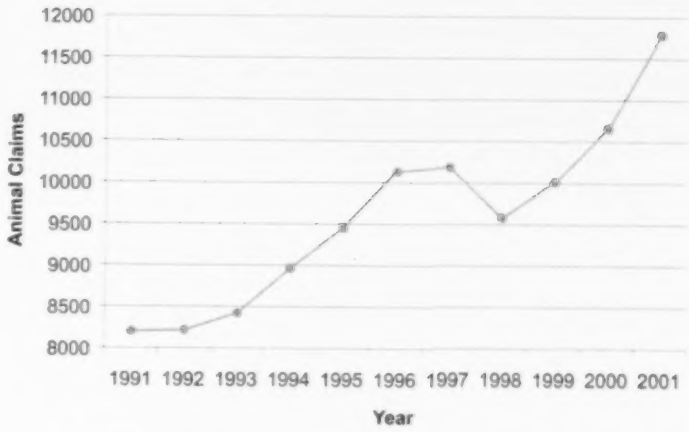
In Saskatchewan's forest regions, some common exotic plant species such as sweet clover, Canada thistle and caragana have invaded along roadsides and logging landings, but the problems they cause are small in scope compared to the multitude of problems posed by exotics in the south. The invasion of exotic weeds into native grasslands is particularly serious in areas such as the Regina plains, where remnant prairie occurs only in very small patches and is surrounded by the exotics. It has now become impossible to save these small native prairie remnants without intensive and costly human intervention.

Smooth brome grass (*Bromus inermis*) is used for hay, for re-vegetating roadside ditches and to control the stem-boring sawfly (*Cephus cinctus*), a serious pest of wheat in the early 1900s. This introduced grass species is one of the most effective invaders of native plant communities, particularly in the Aspen Parkland Ecoregion where it is displacing the native fescue and wheat grasses. Although the treed part of the parkland may remain, the native grass component has been taken over almost totally by brome grass, Kentucky blue grass, crested wheat grass, leafy spurge, Canada thistle and quack grass. These invasive species exclude other plants, resulting in few sources of food and inadequate cover for most prairie animals.

Invasion of cheat grass or downy brome (*Bromus tectorum*) in the Great Sand Hills of southwestern Saskatchewan is compromising biological diversity. In the southwestern United States, this species has created a virtual biological desert wherever it has become established. In addition, it greatly increases the fire hazard because of its quick maturing nature and its tendency to form a monoculture of tinder-dry fuel for prairie fires.

Animal Collisions

Exotic species, such as sweet clover and alfalfa, growing in roadside ditches attract deer and other grazers and are believed to contribute to the large number of wildlife-vehicle collisions on Saskatchewan roads (see following figure). Over the past decade, Saskatchewan Government Insurance claims have risen from approximately 8,200 reported accidents in 1991 to 11,775 in 2001, representing a tremendous mortality of wildlife (mostly deer) and high material damage ($22.7 million in Auto Fund claims in 2002). Saskatchewan Government Insurance claims are only recorded when there is damage to the vehicle involved. Consequently, traffic fatalities of small wildlife such as endangered burrowing owls or swift foxes, species that are very vulnerable while hunting food along roadsides, are never reported (McNaughton, 2002).



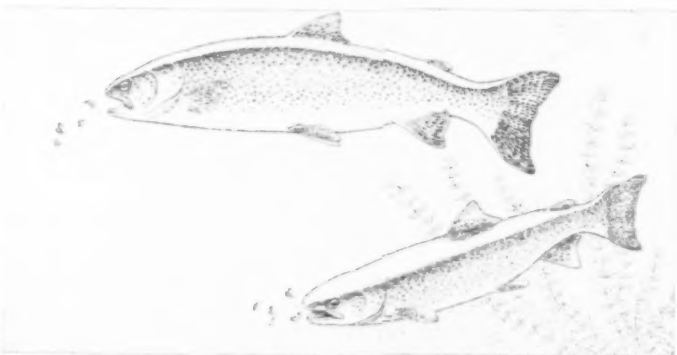
Source: Saskatchewan Government Insurance, 2002.

In aquatic habitats throughout the province, several exotic species jeopardize native species. About 40 small sites in Saskatchewan are being overtaken by purple loosestrife (*Lythrum salicaria)* including sites in Regina, Moose Jaw, Saskatoon and Yorkton (Thorpe and Godwin, 1999). Purple loosestrife, introduced as an ornamental into gardens, is known as the beautiful killer because it squeezes out all other plants in the wetlands it invades. Although its beautiful purple-pink flowers are attractive, this exotic invader is one of the worst threats to wetland biodiversity on the prairies.

The European carp (*Cyprinus carpio*) has invaded the Qu'Appelle River system, invading on its own from Manitoba, where it was likely introduced for aquaculture. It is believed to be gradually replacing the native bigmouth buffalo fish *(Bubalichthyus urus)* that is now considered a species at risk in Saskatchewan. The bigmouth buffalo used to be present in sufficient numbers to support a commercial fishery in the Qu'Appelle lakes.

Exotic insects and microbial pests, mostly introduced from outside Saskatchewan, cause problems for Saskatchewan agricultural producers, homeowners and natural ecosystems. Efforts to control these pests result in the use of pesticides and biological controls that invariably effect native species. A study of native grasslands in Saskatchewan found that non-native beetle species now make up 8 per cent of beetle species diversity. The seven-spotted lady beetle, for example, was introduced by humans to control aphids and is now the dominant lady bird beetle in southern Saskatchewan.

Fish stocking of exotic species, notably trout and salmon species, to enhance sport fishing opportunities, has been common practice in Saskatchewan throughout the years, but only in conditions safe for competing native sport fish. In addition, there are approximately 2,000 landowners who raise non-commercial numbers of rainbow trout in dugouts or farm ponds for recreation or food, although numbers may have diminished in recent years. There are about 20 operators who stock larger pothole lakes with commercial quantities of rainbow trout (from 500 to 10,000 fish) and harvest them for local sale. There have been no short-term negative ecological effects of the managed introduction of these exotic fish to suitable designated waterbodies. Long-term effects of introduced game fish in natural waters are not fully understood.



7.4.8 - Habitat Change

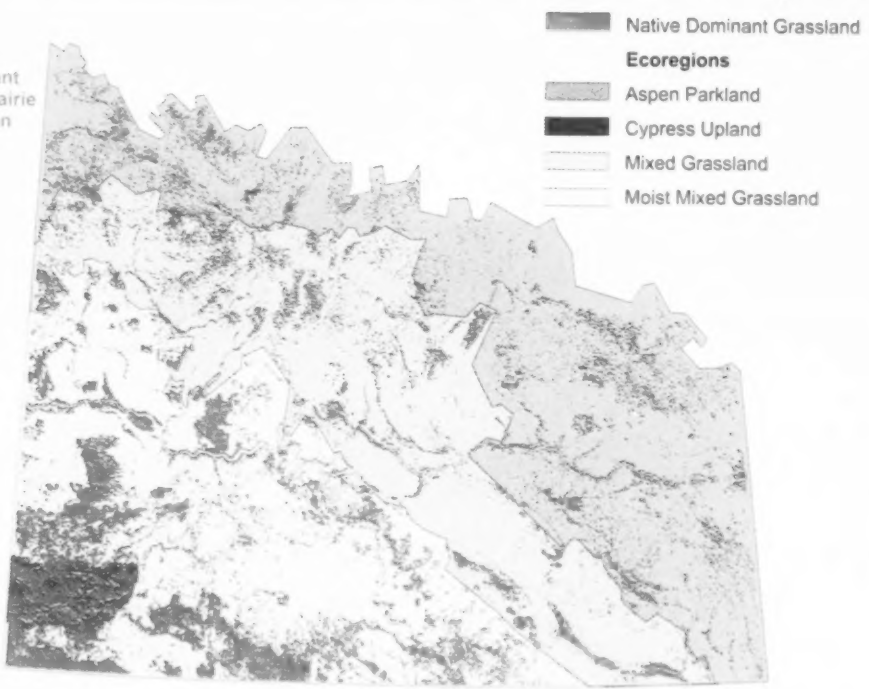
With the exception of occasional creek and river valleys, most of southern Saskatchewan is a level to undulating plain. Virtually all of these vast flatlands have been cultivated for agricultural crop production. Only 21 per cent of the Prairie Ecozone is now classified as native grassland, while 66 per cent is classified as cropland (Hammermeister et al., 2001). See Table 7.7 for the proportion of native grassland and croplands in the ecoregions of the Prairie Ecozone. See Figure 7.9 for locations of native grassland.

Table 7.7 Native Habitat in the Prairie Ecozone of Saskatchewan

	Ecozone/ Ecoregion Area (km^2)	% of Ecozone	Native Dominant Grasslands (% of Ecozone/ Ecoregion)	Croplands (% of Ecozone/ Ecoregion)	Fragmentation of Native Dominant Grasslands
Prairie Ecozone	240,967	-	21	66	Small, fragmented patches
Aspen Parkland Ecoregion	81,692	34	13	70	Highly fragmented and small in size Most fragmented in this ecozone
Moist Mixed Grassland Ecoregion	67,832	28	16	73	Only a small amount remains Highly fragmented and small in size
Mixed Grassland Ecoregion	86,424	36	31	60	Greatest amount of native grassland compared to other ecoregions and accounts for over half of native grasslands in the ecozone. Largest grassland patch in the ecozone. Most patches are relatively small and fragmented but this ecoregion has the largest number of large patches.
Cypress Upland Ecoregion	5,020	2	71 (but only 7% of native grassland in the ecozone)	21	Has second largest native patch in the ecozone. A number of native patches are large and continuous. Typically the native grassland is in small patches and fragmented.

Source: Gauthier et al., 2002

Figure 7.9 Native Dominant Grasslands within the Prairie Ecozone of Saskatchewan



Data Source: Southern Digital Landcover (1994) - Information Services Corp. Sask Research Council

Habitat Monitoring on the Canadian Prairies

It has been estimated that Saskatchewan has lost over 40 per cent of its wetlands in the south since settlement, with the greatest drainage networks existing in the eastern part of the agricultural zone (Thorpe and Godwin, 1999).

Pre-existing habitat lost from permanent flooding after dam construction has also been extensive, especially along the Saskatchewan River systems (Thorpe and Godwin, 1999). On the positive side, the creation of Lake Diefenbaker provided habitat for new species such as lake trout. In addition, with drought drying up large wetlands formerly used by staging migratory waterfowl farther north, Lake Diefenbaker is now used extensively by more than one million ducks, geese and sandhill cranes each fall to rest and feed before continuing their migration. The creation of Lake Diefenbaker has provided suitable nesting conditions for species such as the endangered piping plover. This species nests on the sandy shores in years when water levels are favorable, but the lake acts as an ecological trap if rising water levels flood out the nests.

The Prairie Habitat Joint Venture, North American Bird Conservation Initiative and Environment Canada have begun a habitat monitoring program on the Canadian prairies (see 7.6.6 for more detail on the program) to estimate habitat changes from 1985 inception of the North American Waterfowl Management Plan to 1999. Some results for targeted study areas in Saskatchewan follow.

Wetlands

Between 1985 and 1999, net wetland area loss was estimated to be 2.1 per cent of the total baseline wetland area. Wetland area under cultivation increased by 8 per cent, while the total area of wetlands composed of grasses and/or sedges decreased by 11 per cent.

Uplands

Between 1986 and 1996, of the total cultivated hectares reported in 1986, total cultivated hectares decreased by 1 per cent; total hectares in tame hay increased by 59 per cent; total hectares in natural land being used for pasture decreased by 9 per cent; total hectares in tame pasture increased by 50 per cent; and total hectares in summerfallow decreased by 27 per cent. Between 1985 and 1999, total hectares in shrub habitat increased by 3 per cent, while treed habitat decreased by 2 per cent.

Habitat Changes in the Boreal Transition Ecoregion

Habitat change in the Boreal Transition ecoregion have important implications for biodiversity, land use and carbon sequestration.

Fitzsimmons (2002) found, through comparisons of digitized topographic maps, that the forested area of the Waskesiu Hills landscape was being lost at a rate of 0.19 per cent per year. Forests on agricultural land were cleared at a rate of 1.27 per cent a year from the early 1960s to the early 1990s. In the Red Deer River landscape (near Hudson Bay) forest lost to agriculture between 1957 and 1990 was 1.21 per cent per year for 1957-1990. These deforestation rates on agricultural land are several times the world average.

During the same period, road networks expanded in the two landscapes studied even though the human population declined at a rate of almost 1.2 per cent per year (Fitzsimmons, 2002).

In another study, Hobson et al. (2002) documented the forest loss between 1966 and 1994 for the entire boreal transition zone of Saskatchewan. The study area, which was 4.98 million hectares in size, had 1.79 million hectares of forested land in 1966 and only 1.35 million hectares of forested land in 1994. The average deforestation rate between 1966 and 1994 was 0.89 per cent per year, three times the world average and comparable to Fitzsimmons' study.

Hobson et al. (2002) also examined Canadian Agricultural Census data from 1916-1996 to monitor losses in non-agricultural land in 39 rural municipalities in the boreal transition zone. Findings indicated that from 1916-1996, total non-agricultural land declined from 4.42 million hectares to 1.76 million hectares, an average annual rate loss of 0.75 per cent per year.

7.4.9 - Habitat Protected

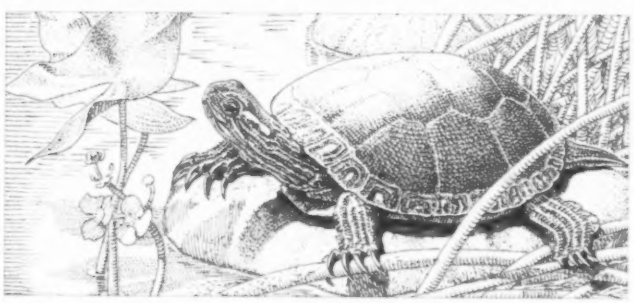
Representative Areas Network (RAN) sites serve as benchmarks or long-term reference points that can be used to measure the impact of management practices being applied outside of the network and conserve samples of the range of biological diversity found in Saskatchewan. The RAN is a network of ecologically important lands and waters that represent the province's landscapes and biological resources. More than 5 million hectares, or just over 8 per cent of the province, have been recognized or designated as part of the RAN. From April 2000 until April 2002, more than one million hectares of land have been recognized or designated as part of the RAN. These new designated lands are diverse, ranging from native grasslands in the south to forested ecosystems in the north. See Table 7.8 for a general summary of protected lands.

Table 7.8 Protected Lands in Saskatchewan in 2002

Jurisdiction	Type	Number	Area (ha)
Provincial			
Saskatchewan Agriculture, Food and Rural Revitalization	Provincial community pastures, WHPA lands	23,993	1,508,370
Saskatchewan Environment	Ecological reserves, FWDF lands, park lands, special management areas, wildlife refuges	1,747	2,546,881
Saskatchewan Wetland Conservation Corporation*		361	910
Other	Provincial heritage properties	3	134
Federal Administration	Migratory bird sanctuaries, national parks, national wildlife areas, PFRA community pastures	127	1,303,939
Municipal	Regional parks, urban park authorities, municipal heritage properties	22	16,427
Corporate		1	1,552
NGO	Ducks Unlimited	-	355,875
Private Land	Conservation easements	78	6,365
Total lands in RAN			5,721,992
Total all protected lands			5,740,453

*Footnote: *Now Saskatchewan Watershed Authority.*
Data Source: Saskatchewan Environment.

With the designation of three Special Management Areas in the far north of the province, representation has been achieved in all 11 of the province's ecoregions. However, several ecoregions remain under-represented, and it will be a priority for the RAN to achieve this representation. Most notable of the under-represented ecoregions is the Athabasca Plain Ecoregion, where less than 3 per cent of the ecoregion is represented.



7.5 - POTENTIAL RISKS TO ECOSYSTEM AND HUMAN HEALTH

The various impacts of human activities and their accumulated disruptions to natural ecosystems can, over time, result in major changes to entire landscapes and ecosystems. Climate change is one such example that is threatening major ecological change in the province. In addition, more linkages are being made between ecosystem health and human health. Although a comprehensive body of information is not yet available linking the two, some studies and trends are emerging. The following section briefly touches on some of these findings.

7.5.1 - Ecosystem Change

Climate change is expected to dry out many parts of Saskatchewan to the extent that whole ecosystems such as those found in the Cypress Hills may be lost within 50 years, and many of southern Saskatchewan's shallow lakes and sloughs will be dry much of the time. The edge of the boreal forest is projected to move northward to approximately the latitude of the Churchill River system. Since climate change effects are expected to vary and are still not well understood, protecting and enhancing biological diversity at all levels is considered to be the best approach to prepare for global warming.

7.5.2 - Contamination of Waterbodies

Aquatic biodiversity is most often immediately affected if poisonous chemicals are released or escape into the natural environment. These chemicals are readily carried by water as it runs off the land, into small streams, then into rivers and lakes, causing damage to wildlife along the way. Surplus nitrogen and phosphorous from feedlots and fertilizers can be washed into waterbodies, leading to eutrophication (extensive algae growth and oxygen deprivation) and eventually to the collapse of entire ecosystems. Because they act as filters, some wetlands have accumulated a poisonous mixture of chemicals in their bottom sediments that will likely remain for hundreds of years unless disturbed.

7.5.3 - Pharmaceuticals and Their Effects on Native Plants and Animals

Pharmaceuticals used as human medicines or to enhance livestock production have recently been identified as a concern. Further research is required to determine if their presence in the natural environment is related to ecological problems such as resistance to disease or incidence of sterility in native plant and animal populations. The drugs or derivatives of the drugs can persist in livestock manure and effluents from human sewage treatment plants and can escape into the natural environment.

7.5.4 - Chronic Wasting Disease

Chronic wasting disease (CWD), or spongeform encephalopathy, is a deadly disease in deer and elk. It was first observed in 1967, at a research facility in Oregon, and eventually determined to be different from, but related to, the scrapie disease in sheep and mad cow disease in cattle. The mad cow disease became of great concern in the UK and Europe when it was linked to Creutzfeldt-Jakob disease in humans. All of these diseases attack the brain of victims and are incurable. Although no connection has ever been recorded between CWD and the human disease, there is potential that CWD could broaden its scope through genetic change and become a problem for other animals, including humans.

Chronic wasting disease has now appeared in game-farmed elk, as well as wild mule and white-tailed deer in Saskatchewan. At present, the only action known to combat the disease is to slaughter and properly dispose of all infected, or potentially infected, deer and elk in the infected area. To date, over 3,000 game farm elk have been put down. The presence of the disease in Saskatchewan makes it difficult to impossible for game farmers to sell their animals.

A program of herd reductions around areas where infected wild deer have been reported has not confined the disease to the area where it was first reported. The disease has now appeared in seven deer, including both mule and white-tailed deer, in western Saskatchewan. It is not known whether the disease will remain endemic and infect very few wild animals or if it will eventually become an epidemic that could decimate the entire wild deer and elk population on the prairies.

7.5.5 - West Nile Virus

West Nile virus (WNV) may have arrived in North America naturally through migration of birds from Europe and Asia or through international trade and travel, and is considered an exotic species. The virus first occurred in New York in 1999, where 62 people were infected and 7 died. This virus is now considered to be widespread in the U.S.A. (Environmental News Service, 2002), and to date, has been found in four Canadian provinces. In the summer of 2002, the virus was identified in Regina and in August of that year, several people in southern Ontario died from the virus. Horses are very vulnerable to the disease. Several horses with WNV had to be put down in southeastern Saskatchewan in 2002.

Humans and animals become infected with WNV through the bite of mosquitoes that have been infected by feeding on infected birds. The virus most commonly kills members of the jay family: crows, ravens, jays and magpies (Health Canada, 2002). In Saskatchewan, in 2002, 44 birds tested positive for the WNV. There were no positive tests from mosquito pools and no known human cases. Most humans in Saskatchewan are at little risk of being bitten by an infected mosquito. The elderly, young and those with weak immune systems are most at risk if they become infected.

7.5.6 - Lyme Disease

In North America, ecosystem disruption has led to the presence of Lyme disease, caused by a bacterium, *Borrelia burgdorferi*, that is carried by ticks. It is thought that the bacterium existed naturally in the environment without causing disease to humans until suburban areas expanded along with white-tailed deer populations, bringing people and deer into closer contact. A decline in predator numbers and milder winters have allowed deer numbers to increase throughout North America, as have rodents, providing habitat for ticks. Humans who walk bare-legged through brush and tall grass in spring and summer are at greatest risk of contracting the disease. This is the time that ticks are most actively seeking a host and can spread the disease.

Lyme disease is being reported with increasing frequency and geographic range throughout Canada and the United States. Most of the cases in Canada have been in Ontario. No human cases of Lyme disease have been identified in Saskatchewan, but the western provinces have all found the Lyme disease bacterium. The recognized tick vectors are not currently found in Alberta or Saskatchewan.

7.5.7 - Hantavirus

The recent eruption and prevalence of hantavirus is thought to be the result of climatic and ecological changes. This virus has spread from the southern United States into Canada. Humans contract the hantavirus disease through the inhalation of airborne particles contaminated by rodent saliva or excretions. The primary carriers in Saskatchewan are deer mice (*Peromyscus maniculatus*).

In Saskatchewan, hantavirus is mostly of concern to farmers and those who handle grain or spend time in rodent-infested buildings. This disease is still very rare. In Canada, to date, there have been 41 cases (16 deaths). In Saskatchewan, seven cases have been reported since 1994 (Bangura, 2002).

7.5.8 - Genetically Modified Organisms

There is some concern that the use of genetically modified organisms may also affect biodiversity and human health, especially in the long term. Many genes are common to all organisms, including humans, and may move from one species to another through viral and bacterial vectors in an uncontrolled and unexpected manner. The potential for allergic reactions has already been demonstrated by a case where nut genes were inserted into soybean plants and then allergic reactions were noted in people who can eat soy but are allergic to nuts.

7.6 - KEY MANAGEMENT ACTIVITIES AND PROGRAMS

7.6.1 - Saskatchewan's Biodiversity Action Plan

The need for biodiversity conservation was formally recognized worldwide in 1992 through the United Nations Convention on Biodiversity. The convention deals with the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the use of genetic resources. Canada's response to the convention was the development of the Canadian Biodiversity Strategy in 1995. This national strategy sets out long-term goals and actions for biodiversity conservation and the sustainable use of biological resources.

Saskatchewan is in the process of completing a provincial Biodiversity Action Plan to build on the objectives outlined in the Canadian strategy. Objectives for conservation of biodiversity must be integrated into resource allocation and management, development assessments and decisions, and policy development. Saskatchewan's Biodiversity Action Plan will serve as an umbrella for a variety of provincial actions to achieve long-term conservation of biodiversity and the maintenance of ecological processes and life support systems.

7.6.2 - Representative Areas Network

Over the past several years, significant progress has been made on the establishment of a Representative Areas Network (RAN) for Saskatchewan. The purpose of the RAN program is to set aside a system of protected or specially managed areas that are representative of all major ecological areas in the province that will be managed to protect habitat and maintain ecological integrity. The number and type of representative areas is outlined in Section 7.4.9 of this report. Work will continue to develop management guidelines for these areas that ensure adequate protection and proper management.

7.6.3 - The National Accord for the Protection of Species at Risk

In 1996, federal, provincial and territorial ministers responsible for wildlife committed to a national approach for the protection of species at risk in Canada. The goal is to prevent species from becoming extinct as a result of human activity. As signatory to the National Accord for the Protection of Species at Risk, Saskatchewan agreed that it would participate in the Canadian Endangered Species Conservation Council to coordinate activities and resolve issues for the protection of species at risk. The council is comprised of federal, provincial and territorial ministers with responsibilities for wildlife species.

7.6.4 - Federal Species at Risk Act

In 2002, the federal *Species at Risk Act* (SARA) was passed. In keeping with the intent of the National Accord for the Protection of Species at Risk, Saskatchewan will ensure that provincial legislation is complementary with the federal act and that overlap and duplication will be avoided. Responsibility for SARA falls to the Minister of Fisheries and Oceans for aquatic species; the Minister of Heritage for species in national parks, national historic sites and other protected heritage areas; and the Minister of the Environment for all other species. How SARA will be implemented in Saskatchewan is still under negotiation.

7.6.5 - Federal Habitat Stewardship Program

The Habitat Stewardship Program for species at risk is one part of a three-part strategy by the Government of Canada to protect species at risk and their habitat. The main goal of the program is to protect habitat and contribute to the recovery of species listed as endangered, threatened or of special concern. Now in its third year, the program has provided assistance and funding for over 25 projects involved in the protection of over 20 COSEWIC-listed species at risk.

7.6.6 - Habitat Monitoring on the Canadian Prairies

Environment Canada (Canadian Wildlife Service) has developed and begun to implement a habitat monitoring program across the prairies. To date, efforts have focused on integrating data from a number of sources to determine habitat changes that have occurred across the Prairie Ecozone since the inception of the North American Waterfowl Management Plan. Baseline habitat measurements were established in 1985 and provide a tool for tracking habitat and land use changes over time. The program also utilizes the Census of Agriculture data, made available by Statistics Canada, to track broad landscape level trends.

Phase I of the program has been completed. For the first time, there is an indication of the rate of wetland losses and magnitude of prairie upland habitat and land use changes that have occurred since 1985. Work is currently underway to update the entire monitoring dataset and examine trend information collected through the latest *2001 Census of Agriculture*.

7.6.7 - Ecosystem-based Management Approach

Saskatchewan Environment has moved from using a single species management practice for species at risk to an ecosystem-based management approach. An ecosystem-based approach recognizes that all things on earth, living and non-living, are interconnected and that most species become endangered because of ecosystem or total environmental impacts, not species-specific impacts.

It is impossible to understand and address all the needs and interrelationships of each species separately, especially ones not well known, such as insects, spiders and other invertebrates. The ecosystem approach recognizes the need for maintaining the habitat needs for the native plants and animals of an area, i.e., its ecological integrity and natural biological diversity. This approach will help prevent additional ecological problems and provide solutions to existing problems further down the road. The traditional tools of species recovery, such as site-specific management activities, captive rearing, re-introduction and translocation, are still employed when appropriate, but applied within an ecosystem context.

7.6.8 - Conservation Data Centre

The Conservation Data Centre (CDC) at Saskatchewan Environment plays a vital role in the collection, storage and dissemination of data about species at risk. Recent research, management and monitoring projects include work on understanding habitat use in long-billed curlews, a provincial count of nesting prairie falcons and a pilot project on the *ex situ* (using a specially designed pond) rearing and release of bigmouth buffalo fish into its natural habitat, the Qu'Appelle River. Consideration is also being given to the possible re-introduction of the black-footed ferret.

7.6.9 - Forest Management Effects Monitoring Program

For the past five years, Saskatchewan Environment has been developing a program to monitor the effects of natural and human-caused disturbances on the long-term health of the forest ecosystem. An example of a natural disturbance is wildfire. An example of a human-caused disturbance is forest harvesting. The premise for the program is that natural disturbances provide the best pattern or template for sustainable forest management. Therefore, this template can be used to manage activities to resemble those conditions resulting from natural disturbances.

To accomplish this difficult objective, the monitoring program is designed to track the long-term results of the two types of disturbances, natural and human-caused. Ultimately, this approach will help managers learn how to mimic nature and promote sustainable forest management.

7.6.10 - Saskatchewan Pasture Programs

There are two pasture programs in the province: the federal Community Pastures Program managed by Prairie Farm Rehabilitation Administration (PFRA) and the Saskatchewan Pastures Program managed by Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR) (Figure 7.10). The purpose of these programs is to supply summer grazing on Provincial Crown lands on a fee-for-service basis. PFRA administers 723,000 ha in Saskatchewan, comprising 595,000 ha (82 per cent) of native rangeland and 128,000 ha (18 per cent) of tame forage. The provincial pasture program comprises 324,000 ha of land.

Both PFRA and SAFRR have entered into several partnerships for ecosystem management and cooperate with numerous public interest groups and wildlife agencies on projects related to specific plant and animal species. Both programs have developed agreements with Saskatchewan Environment to manage their respective community pastures as part of the Representative Areas Network. These efforts make a significant contribution to the conservation of native prairie and natural biodiversity.

Figure 7.10 Saskatchewan and PFRA Community Pastures

Data Source: SAFRR, PFRA

7.6.11 - Fisheries Management

Various strategies are used to protect and recover fisheries resources. Commercial quotas and sport fishing limits are adjusted to reflect changing population levels. Catch-and-release lakes have been in place since the 1990s, along with weight and size restrictions, to relieve pressure on northern lake systems. In the last several decades, stocking has been used most frequently to maintain fisheries populations that are being over-harvested or to re-establish or improve populations.

The provincial hatchery maintains various species of trout brood stock to maintain sport-fishing opportunities in selected streams and smaller lakes. Twenty-one aeration projects are operated around the province by volunteer organizations to aerate shallow waterbodies so that they are capable of supporting fish year-round to provide ongoing recreational fishing opportunities.

More attention is being given to species at risk, such as lake sturgeon and bigmouth buffalo fish, which are suffering from over-harvest and ecological changes resulting from human activities. Stocking species at risk, along with habitat recovery, is improving species and habitats, but significant recovery of watershed integrity is needed for efforts to be successful. Protective regulations and conservation efforts, along with increased monitoring and better data analysis, are helping to manage fisheries resources. However, commercial and recreational fishing activities continue to place heavy demands on the fisheries resource.

7.6.12 - Species Recovery Programs

Saskatchewan has been involved with species at risk recovery plans for a number of years. Among the successes are the re-introduction of the swift fox and the ongoing recovery of the whooping crane. Saskatchewan recently participated in the third North American census of piping plovers that showed its population to be stable or slightly increasing. Saskatchewan was also involved with the production and release of the now-recovered peregrine falcon and has been monitoring the progress of other species such as the loggerhead shrike, burrowing owl, sage grouse and ferruginous hawk.

7.6.13 - Index of Ecological Integrity

One of the key components of ecosystem-based management is the maintenance of ecological integrity. The concept of integrity includes the "wholeness" or "health" of the ecosystem over the long term. To assist in the assessment of ecological integrity, an index is being developed to measure the relative abundance and presence of ecosystem components and look at factors that are known to reduce ecological integrity. These measures are then used as a "relative index" of the state of an ecosystem's integrity. Saskatchewan Environment is currently in the process of developing such an index that will help to improve management practices.

8

Observations and Conclusions

Although Saskatchewan does not have large concentrations of people in large cities and the overall population is small, there have been significant changes to the landscape since the settlement of Europeans over the past century. These changes have direct impacts on the land and soils, water, and native plants and animals (biological diversity). The major industries of agriculture, forestry, mineral extraction (including oil and gas) and manufacturing have significantly impacted the environment. Even in Saskatchewan's wide-open spaces that allow free movement of air, there are concerns about high emissions of greenhouse gases that are believed to be contributing to global climate change.

Stresses on the natural environment impact the province economically and socially, thereby affecting the general quality of living of its residents. The 2003 State of the Environment report has identified the key stresses on Saskatchewan's natural environment. The condition of air, land (soils), water and biological diversity has been examined, and responses to deal with perceived problems have been reported.

Air quality is generally good in Saskatchewan. Conditions of smog are rare but acid precipitation from industry in Alberta is a potential future problem, especially for parts of northern Saskatchewan.

Airborne particulates such as blowing dust and smoke from forest or stubble fires are the most noticeable air pollution. Air quality has been monitored at Cree Lake in Northern Saskatchewan and, in the near future, will be at Bratt's Lake (near Regina). An Air Pollution Index is used to monitor long-term trends in air quality.

There is considerable concern about the level of provincial greenhouse gas emissions. These have increased by 32 per cent between 1990 and 2000 and are forecast to increase by another 13 per cent by 2020. Saskatchewan is working to reduce its greenhouse gas emissions. This effort includes programs to reduce emissions from electricity production, including greater use of green energy sources such as wind and natural gas, greater use of ethanol in gasoline, and initiatives for businesses and individuals to be more energy conscious and efficient.

Almost one-half of the Saskatchewan land mass is devoted to agricultural production. This conversion of native grasslands and parklands to cultivated crops and hay has greatly modified the environment as a whole, especially in southern Saskatchewan.

In the area of the Boreal Plain Ecozone, forestry is the major land use. Significant influences are also exerted by mining, oil and gas development, tourism and outdoor recreation, and agricultural clearing along the forest fringe. The far north is largely pristine wilderness, but this area also has environmental challenges related to mining and the occasional over-harvesting of game and fish species.

All areas are significantly affected by the presence of roads of all kinds. Roads segment and disrupt the landscape and transport not only goods and services from place to place but also pollution, garbage and unwanted plant and animal species.

A number of land use practices impact the health of the land in Saskatchewan. Widespread use of pesticides and fertilizers is worrisome to many people. There is a major concern about desertification and salinization in parts of southern Saskatchewan, problems that are most acute in times of drought. The recent increase in the number of intensive livestock operations, or factory farms, is also of concern.

Most of the major land use issues have been identified and steps are being taken to address them. Better agricultural management practices (reducing tillage, thus storing more organic matter in the soil) are quickly being adopted. Integrated pest management is replacing wholesale use of pesticides. Growth of reduced tillage and organic farming recognizes the need for protecting and husbanding the valuable soil resource. Intensive livestock operations are closely regulated, and new technologies are continuously being developed to manage manure, odor and water concerns.

The mining and petroleum industries are closely regulated to ensure that new mining and petroleum developments leave no long-term environmental effects. A program to clean up decommissioned mine sites is currently in place. In addition, a program is now in place to clean up old contaminated industrial sites using the "polluter pays" principle.

Saskatchewan has established a Municipal Solid Waste Management Assistance Program to deal with solid waste at the regional level. In addition, SARCAN, the Saskatchewan Scrap Tire Corporation and other private companies are expediting the principles of the 4Rs (reduce, re-use, re-cycle and recover).

In Saskatchewan, water is supplied to the public either from surface waters in lakes, rivers, streams or dugouts, or as groundwater that is accessed by wells. Groundwater is often stored in aquifers (underground lakes) of various sizes.

Contamination of water is a constant concern, especially in groundwater, where persistent pollutants can move long distances into waterbodies and wells. The growth of urban centres and a growing number of intensive livestock operations increase the chances of pollution.

Erosion resulting from agricultural practices, forestry, mining, oil and gas production, and roads also pose water quality challenges in Saskatchewan's lakes and streams. Eutrophication, or the buildup of nutrients, in these waterbodies causes odor, potential disease and mortality problems.

A monitoring program has shown that both the mountain-fed North and South Saskatchewan rivers have good to excellent water quality. The Qu'Appelle River system, fed largely from runoff from agricultural fields, has lower quality water but is still suitable for contact recreation such as swimming.

Various levels of government are working to ensure that everyone involved with water supply and use are meeting water quality standards and treatment criteria. Although general acceptance of tougher standards and regulations has been good, continuing vigilance and complete compliance is needed to ensure that public health issues, such as the *Cryptosporidium* outbreak in North Battleford, do not happen again.

In most cases, point source contamination is being dealt with, but pollution of water supplies from the general environment remains a challenge. To address this issue, the Saskatchewan Water Corporation is providing assistance to communities to ensure their water systems are safe. Saskatchewan Environment has also assumed a stronger regulatory responsibility.

The newly created Saskatchewan Watershed Authority will address water management from an ecosystem management perspective, recognizing that water supply and quality is linked to many natural and unnatural factors in the environment. One of the agency's initial objectives is to build commitment to water stewardship initiatives through stakeholder groups.

In the southern half of Saskatchewan, biodiversity has been in decline for more than 100 years. It began with the extirpation of large animals like the bison, then the loss of more than 75 per cent of all natural grasslands and parklands to agricultural production. Forty per cent of the wetlands were drained, and roads have dissected and fragmented the landscape. That which remains is a mere remnant of what used to be a highly diverse and biologically productive ecosystem.

Stresses on Saskatchewan's biodiversity continue. Agricultural clearing and breaking continues in the forest fringe area. Agricultural and industrial pesticides, fertilizers and wastes pose hazards to soil and aquatic organisms. Forest harvesting challenges biodiversity, particularly on "not sufficiently restocked" lands, and rapid climate change will significantly degrade habitats for many plants and animals. As natural habitat has been reduced in size and scope, the introduction of exotic plants and animals has become more detrimental to native species.

Game species have generally maintained viable populations. Elk populations have increased steadily. But those with specialized requirements, such as pronghorn antelope, woodland caribou, pintail ducks and scaup ducks are suffering population declines. Breeding bird survey trends for the past 20 years have also shown continuing declines in both forest and prairie nesting songbirds.

Saskatchewan is home to over one-third of the vertebrate animals on the national species at risk list (COSEWIC). Efforts to recover these species, along with a long list of rare plants, is having mixed results. Species such as the burrowing owl still appear to be in decline in Saskatchewan. Efforts to recover the swift fox and whooping crane have been more successful.

New threats to ecosystems have appeared in the past decade. These are in the form of diseases such as chronic wasting disease in deer and West Nile virus in birds, horses and humans. The increasing use of genetically modified organisms may also increase the risk of ecological problems such as unwanted hybridization.

Society has, in the last few years, begun to recognize the extent and significance of the loss of native habitats and non-game species. Measures have been taken to save what is left and restore habitat where possible. Adopting an ecosystem-based approach to resource management and environmental protection is another effort to ensure ecosystem stewardship, sustainable use and restoration of ecosystems.

An index of ecological integrity is being developed to provide baseline data and benchmarks against which to measure future actions. The federal legislation for protection of species at risk is being integrated with *The Wildlife Act* of Saskatchewan to implement endangered species programs. Habitat stewardship programs involving private landowners, all levels of government, various non-government organizations and others are working to protect habitat either as part of the Representative Areas Network (RAN) or through various other stewardship programs. The Saskatchewan Conservation Data Centre provides baseline data about all known species at risk. It is striving to include data on ecological communities and organisms, such as threatened insects, spiders and other invertebrates, that perform essential ecological services.

The state of Saskatchewan's environment is still strong, despite the described problems and threats. Programs, regulations and activities are in place to restore and conserve our highly valued natural resources. Monitoring of the health of Saskatchewan's environment will continue to ensure that the province maintains its current ecological health and resources for future generations.

If you have any comments or questions about this report, or suggestions on how such SOE reports could better serve your needs, please write us at:

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APPENDIX I

DESCRIPTION, ESTIMATED HUMAN POPULATION, MAJOR HUMAN ACTIVITIES, IMPACTS AND ENVIRONMENTAL ISSUES OF THE FOUR ECOZONES OF SASKATCHEWAN

	Taiga Shield Ecozone	Boreal Shield Ecozone	Boreal Plain Ecozone	Prairie Ecozone
Landscape	Glaciers have shaped this landscape of lakes, rock outcrops, swamps, wetlands and bogs. Stunted black spruce and tamarack forests with lichen and feather moss understories are common. In places, ancient Precambrian rocks rise 100 m from surrounding rolling landscape, giving a rugged, almost mountainous appearance.	This is a land of water and forest. Typical of the Precambrian Shield, the landscape is characterized by a mix of rock outcrops and lakes, created by the repeated scraping and gouging of numerous glaciations. Lakes account for as much as 40% of the area, are typically long and narrow and are linked by stretches of fast-flowing rivers. Broadly rolling uplands and lowlands support low-growing stands of black spruce and jack pine with feather moss undertstories. Bogs occupy low-lying areas.	This landscape has a subdued rolling appearance, with a few prominent uplands (e.g., Pasquia Hills). Large and small shallow, productive lakes are abundant. Glacial deposits cover most of the sedimentary bedrock. Dominated by the vast boreal forest of white and black spruce, jack pine, tamarack, white birch and aspen, the forests grow taller here than elsewhere in the province. Agriculture dominates the southern 25% of ecozone.	Glacial deposits cover sedimentary bedrock. Bedrock is exposed in incised valleys and major uplands (Cypress Hills, Moose Mountain). Once dominated by native grasses, grain fields now occupy the vast sweep of treeless plains freckled with marshes and aspen groves. In the southwest, the landscape is a dry, treeless grassland with sand dunes and intermittent badlands. To the north, the land changes to rolling plains cut by coulees and broad river valleys (e.g., Qu'Appelle, S. Saskatchewan, Souris). Further north, the land changes to a mosaic of grasslands and aspen before it meets the boreal forest. Forests occur in Cypress Hills (lodgepole pine) and Moose Mountain (aspen).
Climate	Long, cold winters (-27°C in January). Short summers (16°C in July). 96-105 frost-free days. Up to 18.5 h of sunlight per day in the summer. Low precipitation (365 mm/year).	Long, cold winters (-23.5°C in January). Short, cool summers (16°C in July). 94-97 frost-free days. Up to 18 h of sunlight per day in the summer. Precipitation levels range from 451-521 mm/year.	Long, cold winters (-18.9 to -21.4°C in January). Short, warm summers (16.3-17.4°C in July). 91-114 frost-free days. Precipitation levels vary (average 452 mm/year) and decrease south to north.	Long, cold winters (-12.1 to -18.9°C in January). Short, hot summers (18-18.9°C in July). 106-112 frost-free days, 52 frost-free days in Cypress Hills. Low precipitation levels (352-450 mm/year). Frequent winds cause high evaporation and wind chill levels.
Common Wildlife	• arctic fox, gray wolf, lynx, masked shrew, snowshoe hare, wolverine • blackpoll warbler, gray jay, spruce grouse, willow ptarmigan • arctic grayling, northern pike, walleye • wood frog	• beaver, black bear, caribou, lynx, mink, moose • bald eagle, boreal chickadee, common raven, hermit thrush, pileated woodpecker • arctic grayling, walleye, whitefish • boreal chorus frog	• black bear, elk, gray wolf, marten, moose, red squirrel, white tailed deer • blue jay, common loon, common raven, great gray owl, mallard, ovenbird ruffed grouse • fathead minnow, goldeye, northern pike • boreal chorus frog, red-sided garter snake	• badger, red fox, Richardson's ground squirrel, white-tailed deer • American avocet, burrowing owl, magpie, mallard, Swainson's hawk, vesper sparrow, western meadowlark • burbot, walleye, yellow perch • plains garter snake, wood frog

(Continued next page)

DESCRIPTION, ESTIMATED HUMAN POPULATION, MAJOR HUMAN ACTIVITIES, IMPACTS AND ENVIRONMENTAL ISSUES OF THE FOUR ECOZONES OF SASKATCHEWAN

	Taiga Shield Ecozone	Boreal Shield Ecozone	Boreal Plain Ecozone	Prairie Ecozone
Estimated Human Population (2001)*	1,700	17,000	169,000	792,000
Major Human Activities	• mineral exploration • subsistence gathering, hunting, trapping and fishing • support and community Services	• forestry • mineral exploration • mining (uranium, gold, heavy metals) • subsistence gathering, hunting, trapping and fishing • support and community Services • tourism (ecotourism, sport hunting and fishing) • wild rice cultivation	• agriculture (crops, livestock) • commercial fisheries • forestry • mining and mineral exploration • oil and gas production and exploration • power generation • tourism (ecotourism, sport hunting and fishing) • urban settlements (manufacturing, services)	• agriculture (crops, livestock) • commercial fisheries • mining (potash, coal, minerals, aggregates) • oil and gas production and exploration • power generation • tourism (ecotourism • sport hunting and fishing) • urban settlements (manufacturing, services)
Human Impacts (Past and Present)	• habitat alteration • invasive species • localized pollution from mining • harvesting of species • waste generation	• habitat alteration • invasive species • localized pollution from mining and forestry • harvesting of species • waste generation	• air pollution from industry, power use and generation, and vehicles • habitat loss and alteration • invasive species • localized pollution from mining, forestry, oil and gas, and agriculture • harvesting of species • waste generation	• air pollution from industry, power use and generation, and vehicles • habitat loss and alteration • invasive species • localized pollution from mining, oil and gas, and agriculture • harvesting of species • waste generation
Key Environmental Concerns or Issues**	• chemical use • climate change • hazardous waste • population growth • potable water • trapping • unregulated resource use • wildfire effects on human health and property	• chemical use • climate change • forestry management • hazardous waste • population growth • potable water • trapping • unregulated resource use • wildfire effects on human health and property	• acid rain (future) • air pollution from wood processing and burning • allocation of natural resources • biodiversity and species at risk conservation • chemical use • climate change • forestry management • habitat loss and alteration • hazardous waste and Contaminants • potable water • wildfire effects on human health and property • wildfire management	• allocation of natural resources • biodiversity and species at risk conservation • chemical use • climate change • commercial use of fish and wildlife • habitat loss and alteration • hazardous waste and contaminants • invasive species • oil and gas development • pollution from coal power generation • potable water • potash mining waste • provincial park use and management • soil loss/erosion • surface and groundwater quality • urbanization • wildfire management

** Human population figures are based on the 2001 Census by Statistics Canada. These are estimates because ecozone boundaries did not correspond with census division boundaries used by Statistics Canada.*
*** The listed key environmental concerns or issues are based on risk assessments completed by Saskatchewan Environment staff.*
Source: Acton et al., 1998.

APPENDIX 2

PRODUCING AND SUSPENDED MINES AND/OR MILLS IN SASKATCHEWAN

Commodity(s)	Mine/Mill Name	General Location
Base Metal	Konuto Lake	Amisk Lake area
Base Metal	Callinan (Saskatchewan portion)	Amisk Lake area
Bentonite	Canadian Clay Products Ltd.	Wilcox
Clay	Inland Cement Ltd.	Regina
Clay	Estevan Brick Ltd. (4 quarries)	Southwestern Saskatchewan
Coal	Bienfait	Bienfait
Coal	Boundary Dam	Estevan
Coal	Poplar River	Coronach
Gold	Seabee	East-Central Saskatchewan
Moss Peat	Carrot River Peat	Carrot River
Potash, (Salt)	Agrium Vanscoy Potash	Vanscoy
Potash, (Salt)	I.M.C. Potash Colonsay ULC	Colonsay
Potash, (Salt)	I.M.C. Canada Ltd. Belle Plaine	Belle Plaine
Potash, (Salt)	I.M.C. Esterhazy K-1	Esterhazy
Potash, (Salt)	I.M.C. Esterhazy K-2	Esterhazy
Potash, (Salt)	PCS Potash Allan Division	Allan
Potash, (Salt)	PCS Potash Cory Division	Saskatoon
Potash, (Salt)	PCS Potash Lanigan Division	Lanigan
Potash, (Salt)	PCS Potash Rocanville Division	Rocanville
Potash, (Salt)	PCS Potash Patience Lake Division	Saskatoon
Potassium Sulphate	Big Quill Lake Plant	Kandahar
Potassium Sulphate	Alsask Plant	Alsask
Salt	Canadian Salt Plant	Belle Plaine
Salt	Sifto Canada Inc.	Unity
Salt	Sterling Pulp Chemicals	Saskatoon
Silica Sand	Daren Industries Ltd. (suspended)	East-Central Saskatchewan
Sodium Sulphate	Chaplin Plant	Chaplin
Sodium Sulphate	Palo Plant	Palo
Uranium	Cluff Lake	Northwestern Saskatchewan
Uranium	McClean Lake	Northeastern Saskatchewan
Uranium	Key Lake	North-Central Saskatchewan
Uranium	McArthur River	North-Central Saskatchewan
Uranium	Rabbit Lake (suspended)	Northeastern Saskatchewan

Footnote: There will be at least four active uranium mines in 2003 - Rabbit Lake, McLean Lake, McArthur River and Key Lake. Cluff Lake stopped mining in July 2002 and milling in December 2002.
Source: Saskatchewan Industry and Resources, 2002.

APPENDIX 3

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Achillea millefolium var *megacephala*	Large-headed wooly yarrow	G5, T1	S1	Special concern (2000)
Acipenser fulvescens	Lake sturgeon	G3, G4	S2	Not at risk (1986)
Adoxa moschatellina	Musk-root	G5	S3	
Aechmophorus clarkii	Clark's grebe	G5	S1B, SZN	
Agrostis mertensii	Northern bent-grass	G5	S1, S2	
Alisma gramineum	Narrow-leaved water plantain	G5	S3	
Allium cernuum	Nodding onion	G5	S1, S2	
Allium geyeri	Geyer onion	G4, G5	S1	
Allium schoenoprasum var *sibiricum*	Siberian or wild chives	G5, T5	S2	
Alopecurus alpinus ssp *glaucus*	Mountain foxtail	G5, T?	S1	
Alopecurus carolinianus	Carolina foxtail water-foxtail	G5	S1	
Alopex lagopus	Arctic fox	G5	S3	NIAC*
Ambloplites rupestris	Rock bass	G5	S2, S3	
Ambrosia acanthicarpa	Bur ragweed	G5	S2	
Ameiurus nebulosus	Brown bullhead	G5	S3	
Ammodramus bairdii	Baird's sparrow	G4	S3B, SZN	Not at risk (1996); threatened (1989)
Anaphalis margaritacea	Pearly everlasting	G5	S2	
Andromeda polifolia var *glaucophylla*	Glaucous-leaved bog-rosemary	G5, T5	S2	
Andropogon gerardii	Big bluestem or turkeyfoot	G5	S3, S4	
Anemone parviflora	Small-flowered anemone	G5	S1	
Anemone quinquefolia	Wood anemone	G5	S2?	
Anemone quinquefolia var *bifolia*	Wood anemone	G5, T5	S2	
Anemone richardsonii	Yellow or Richardson's anemone	G5	S1	
Antennaria anaphaloides	Tall pussy-toes	G5	S2	
Antennaria corymbosa	Flat-topped pussy-toes	G5	S1	
Antennaria dimorpha	Low pussy-toes	G5	S2	
Antennaria howellii	Howell's everlasting	G5	S2?	
Antennaria howellii ssp *neodioica*	Tomentose or northern pussy-toes	G5, T5	S2	
Antennaria russellii	Russell's everlasting	G?, Q	S2?	
Antennaria umbrinella	Brown-bracted pussy-toes	G5	S2, S3	
Arabis arenicola	Arctic rock-cress	G4	S2	
Arceuthobium pusillum	Dwarf mistletoe	G5	S1	
Arctostaphylos rubra	Red alpine bearberry	G5	S3	
Ardea herodias	Great blue heron	G5	S3B, SZN	
Arenaria congesta	Capitate sandwort	G5	S3	
Arenaria congesta var *lithophila*	Rocky ground sandwort	G5, T?	S3	
Arethusa bulbosa	Swamp-pink or dragon's-mouth orchid	G4	S1	
Aristida purpurea	Red three-awn grass	G5	S1	
Armeria maritima ssp *interior*	Inland sea-thrift	G5, T1, T2	S1, S2	Special concern (1999)
Arnica angustifolia	Arctic arnica	G5	S1?	
Arnica angustifolia ssp *angustifolia*	Narrow-leaf leopardbane	G5, T5	S1?	
Arnica cordifolia	Heart-leaved arnica	G5	S3	
Arnica lonchophylla	Spear-leaved arnica	G4	S2, S3	
Arnica lonchophylla ssp *lonchophylla*	Spear-leaved arnica	G4, T4	S2, S3	
Artemisia tilesii ssp *elatior*	Mountain sagewort	G5, T5	S1	
Asclepias syriaca	Silky milkweed	G5	S1	
Asclepias verticillata	Whorled milkweed	G5	S1	
Aster eatonii	Eaton aster	G5	S1	
Aster modestus	Large northern aster	G5	S2	
Aster pauciflorus	Few-flowered aster	G4	S3	
Aster umbellatus	Flat-topped white aster	G5	S3	
Aster umbellatus var *pubens*	Flat-top white aster	G5, T5	S3	
Astragalus aboriginum	Indian milk-vetch	G5	S2	
Astragalus bodinii	Yukon milk-vetch	G4	S1	
Astragalus kentrophyta var *kentrophyta*	Spiny/prickly milk-vetch	G5, T4	S1	
Astragalus lotiflorus	Low or lotus milk-vetch	G5	S3	
Astragalus purshii var *purshii*	Pursh's milk-vetch	G5, T5	S2	
Astragalus racemosus var *racemosus*	Racemose milk-vetch/ creamy poison-vetch	G5, T5	S2	
Astragalus spatulatus	Tufted or draba milk-vetch	G5	S2, S3	
Astragalus vexilliflexus	Bent- or few-flowered milk-vetch	G4	S2	
Athene cunicularia	Burrowing owl	G4	S2B, SZN	Endangered*; Endangered (1995)
Athyrium filix-femina ssp *angustum*	Northern lady-fern	G5, T5	S3?	
Atriplex powellii	Powell's saltbush or silverscale	G4	S1	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Atriplex truncata	Wedge-scale saltbush	G5	S1	
Atriplex x aptera	Four-wing saltbush or shadscale	HYB	S1	
Atrytonopsis hianna	Dusted skipper	G4, G5	S2	
Besseya wyomingensis	Kitten-tails	G5	S1	
Bidens frondosa	Tall beggar's-ticks	G5	S2, S3	
Boisduvalia glabella	Smooth spike-primrose	G5	S2	
Boltonia asteroides	Aster-like boltonia	G5	S2?	
Boltonia asteroides var *recognita*	Aster-like boltonia	G5, T?	S2	
Bos bison	Bison	G4	S3	
Bos bison bison	Bison	G4, TU	S3	
Botrychium ascendens	Triangle-lobe moonwort	G2, G3	S1	
Botrychium campestre	Prairie dunewort or plain's grape-fern	G3	S1	
Botrychium hesperium	Western moonwort or chamomile-leaved grape-fern	G3	S1	
Botrychium lanceolatum var *lanceolatum*	Triangle grape-fern or moonwort	G5, T4	S1	
Botrychium lunaria	Common moonwort or moon-fern	G5	S1	
Botrychium minganense	Mingan moonwort or grape-fern	G4	S1	
Botrychium multifidum	Leathery or broadleaf grape-fern	G5	S3	
Botrychium pallidum	Pale moonwort	G3	S1	
Botrychium paradoxum	Peculiar or paradox moonwort	G2	S1	
Botrychium pedunculosum	Stalked moonwort	G2, G3	S1	
Botrychium simplex	Least grape-fern	G5	S1	
Bouteloua curtipendula	Tall side-oats grama	G5	S3	
Bubulcus ibis	Cattle egret	G5	S1B, SZN	
Buchloe dactyloides	Buffalo grass	G4, G5	S1	Special concern (1998)
Calamagrostis lapponica var *nearctica*	Lapland reed-grass	G5, T?	S2, S3	
Calamagrostis purpurascens	Purple reed-grass	G5?	S2	
Calamagrostis rubescens	Pine grass or pine reed-grass	G5	S2	
Calypso bulbosa var *americana*	Fairy slipper	G5, T5?	S3	
Camissonia andina	Upland evening-primrose or andean sundrops	G4	S1	
Camissonia breviflora	Short-flower suncup or taraxia	G5	S1	
Campanula aparinoides	Marsh bellflower	G5	S2, S3	
Caprimulgus vociferus	Whip-poor-will	G5	S3B, SZN	
Cardamine parviflora	Small bitter cress	G5	S1	
Cardamine parviflora var *arenicola*	Sand bitter cress	G5, T5	S1	
Cardamine pratensis	Cuckooflower; meadow or cuckoo bitter cress	G5	S2	
Carex abdita	Hidden or umbellate sedge	G3, G5, Q	S2	
Carex alopecoidea	Foxtail sedge	G5	S2	
Carex arcta	Bear sedge	G5	S1	
Carex assiniboinensis	Assiniboia sedge	G4, G5	S2	
Carex bicolor	Two-color sedge	G5	S1	
Carex bigelowii	Bigelow's sedge	G5	S1	
Carex buxbaumii	Brown sedge	G5	S2	
Carex crawei	Crawe's sedge	G5	S1	
Carex cristatella	Small-crested sedge	G5	S1	
Carex cryptolepis	Yellow sedge	G4	S1	
Carex eburnea	Bristle-leaved sedge	G5	S2	
Carex echinata ssp *echinata*	Prickly sedge	G5, T5	S1	
Carex garberi	Garber's sedge	G4	S2	
Carex glacialis	Glacier sedge	G5	S1	
Carex granularis	Granular sedge	G5	S2	
Carex gravida var *gravida*	Heavy-fruited sedge	G5, T5?	S1	
Carex heleonastes	Hudson bay sedge	G4	S2	
Carex hoodii	Hood's sedge	G4, G5	S2	
Carex hystericina	Porcupine sedge	G5	S2	
Carex laxiflora var *blanda*	Woodland sedge	G5?	S1	
Carex laxiflora var *varians*	Pleasing sedge	G5, T?, Q	S1	
Carex mackenziei	Mackenzie sedge	G4?	S1	
Carex maritima	Seaside sedge	G4, G5	S1	
Carex michauxiana	Michaux sedge	G5	S1	
Carex pachystachya	Thick-spike sedge	G5	S3	
Carex pauciflora	Few-flowered sedge	G5	S2	
Carex pedunculata	Long-stalked sedge	G5	S1	
Carex petasata	Caespitose or tufted sedge	G5	S2	
Carex projecta	Necklace sedge	G5	S1	
Carex pseudocyperus	Cyperus-like sedge	G5	S2, S3	
Carex raynoldsii	Raynolds sedge	G5	S1	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Carex saxatilis	Rocky ground or bubble sedge	G5	S2	
Carex supina var *spaniocarpa*	Weak arctic sedge	G5, T?	S1	
Carex tetanica	Rigid sedge	G4, G5	S1	
Carex trisperma	Three-fruited sedge	G5	S2	
Carex vulpinoidea	Fox sedge	G5	S2	
Carpiodes cyprinus	Quillback	G5	S3, S4	
Castilleja coccinea	Scarlet paintbrush	G5	S1	
Castilleja raupii	Purple or northern paintbrush	G5?	S2	
Catostomus platyrhynchus	Mountain sucker	G5	S3	Not at risk (1991)
Celastrina neglecta	Summer azure	G5	S3	
Celastrus scandens	Climbing bittersweet	G5	S1	
Centrocercus urophasianus	Sage grouse	G4	S1B, SZN	Endangered*; Endangered (1998)
Centunculus minimus	Chaffweed	G5	S2	
Cerastium alpinum	Alpine chickweed	G5?	S1	
Cerastium alpinum var *strigosum*	Alpine mouse-ear chickweed	G5?, T?	S1	
Cerastium beeringianum	Beering's chickweed	G5	S1	
Cerastium beeringianum ssp *terrae-novae*	Newfoundland chickweed	G5, T4?	S1	
Chaetura pelagica	Chimney swift	G5	S3B, SZN	
Chamaesyce serpens	Round-leaved spurge	G5	S1	
Charadrius alexandrinus	Snowy plover	G4	S1B, SZN	
Charadrius melodus	Piping plover	G3	S3B, SZN	Endangered*; Endangered (1985)
Charadrius montanus	Mountain plover	G2	S1	Endangered (1987)
Charadrius semipalmatus	Semipalmated plover	G5	S1B, SZN	
Chelydra serpentina	Snapping turtle	G5	S3	
Chenopodium desiccatum	Dry goosefoot	G5	S2	
Chenopodium hians	Gaping goosefoot	G5	S1	
Chenopodium incanum	Hoary goosefoot	G5	S1?	
Chenopodium subglabrum	Smooth arid goosefoot	G3, G4	S2	Special concern (1992)
Chenopodium watsonii	Dakota stinking goosefoot	G5	S2	
Chimaphila umbellata	Pipsissewa	G5	S3?	
Chimaphila umbellata ssp *occidentalis*	Western Prince's-pine	G5, T5	S2, S3	
Chlosyne harrisii hanhami	Harris' checkerspot	G4, T2	S2	
Chrysosplenium iowense	Iowa golden saxifrage	G3, G4	S1?	
Cicindela nevadica		G5	S3	
Cirsium drummondii	Short-stemmed thistle	G5	S3	
Cirsium muticum	Swamp thistle	G5	S2	
Cladium mariscoides	Twig-rush	G5	S1	
Claytonia lanceolata	Lance-leaved spring-beauty	G5	S2, S3	
Clematis occidentalis	Western blue virgin's-bower	G5	S2?	
Clematis occidentalis var *grosseserrata*	Western purple virgin's-bower or clematis	G5, T4, T5	S2	
Coeloglossum viride var *virescens*	Long-bracted green bog orchid or frog-orchis	G5, T5	S3, S4	
Collinsia parviflora	Blue-eyed Mary or blue-lips	G5	S2	
Coluber constrictor	Yellow-bellied racer	G5	S3	Special concern (1991)
Coluber constrictor flaviventris	Eastern yellow-bellied racer	G5, T5	S3	
Corallorhiza striata var striata	Striped coral-root	G, T4, T5	S2, S3	
Coregonus zenithicus	Shortjaw cisco	G3	S1	Threatened (1987)
Corispermum americanum var *americanum*	American bugseed	G5?, T5?	S2	
Corispermum nitidum	Neat bugseed	GU	S2?	
Coturnicops noveboracensis	Yellow rail	G4	S3B, SZN	Special concern (1999)
Crataegus douglasii var *douglasii*	Black hawthorn	G5, T4	S2	
Crataegus succulenta	Long-spined hawthorn	G5	S1	
Crepis atribarba	Dark hawk's-beard	G5	S1	
Crepis intermedia	Small-flowered hawk's-beard	G5	S1?	
Crepis occidentalis	Western hawk's-beard	G5	S2	
Crepis occidentalis ssp *costata*	Large-flower hawk's-beard	G5, T?	S2	
Crepis runcinata ssp *hispidulosa*	Smooth hawk's-beard	G5, T?	S1?	
Crotalus viridis	Prairie rattlesnake	G5	S3	
Crotalus viridis viridis	Prairie rattlesnake	G5, T5	S3	
Cryptantha celosioides	Clustered oreocarya or cryptanthe	G5	S1	
Cryptantha kelseyana	Kelsey's cryptanthe	G4	S2	
Cryptantha minima	Small cryptanthe	G5	S1	
Cuscuta coryli	Hazel dodder	G5	S1?	Endangered*; Endangered (1998)

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

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Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Cygnus buccinator	Trumpeter swan	G4	S1B, SZN	Not at risk (1996); special concern (1978)
Cygnus columbianus	Tundra swan	G5	S1B, SZN	
Cynoglossum virginianum	Wild comfrey	G5	S1	
Cynoglossum virginianum var *boreale*	Northern wild comfrey	G5, T4	S1	
Cynomys ludovicianus	Black-tailed prairie dog	G4	S2	Special concern (2000) (1999) (1998)
Cyperus aristatus var *aristatus*	Awned umbrella sedge	G5, T?	S1	
Cyperus schweinitzii	Schweinitz's flatsedge	G5	S2	
Cypripedium arietinum	Ram's-head lady's-slipper	G3	S1	
Cypripedium montanum	Mountain lady's-slipper	G4, G5	S1	
Cypripedium passerinum	Sparrow's-egg lady's-slipper	G4, G5	S2	
Cypripedium pubescens	Large yellow lady's-slipper	G5	S2	
Cypripedium reginae	Showy lady's-slipper	G4	S1	
Cystopteris montana	Mountain bladder fern	G5	S1	
Dalea villosa var *villosa*	Hairy prairie clover/ silky prairie clover	G5, T?	S1	Endangered*; Threatened (1998)
Danaus plexippus	Monarch	G4	S3B, SZN	Special concern (1997)
Danthonia californica var *americana*	California wild oat grass	G5, T?, Q	S2	
Danthonia unispicata	Few-flowered or one-spiked oat grass	G5	S2	
Delphinium bicolor ssp *bicolor*	Flat-head larkspur	G4, G5, T?	S, S3	
Delphinium glaucum	Tall or pale larkspur	G5	S1, S2	
Dendroica caerulescens	Black-throated blue warbler	G5	S2B, SZN	
Deschampsia mackenzieana	Mackenzie hairgrass	G2, Q	S2	Special concern (1999)
Dichanthelium acuminatum var *fasciculatum*	Hairy or woolly panic-grass	G5, T5	S2	
Dichanthelium leibergii	Leiberg's witchgrass or panic-grass	G5	S1	
Dichanthelium wilcoxianum	Sand-millet or witch grass	G5	S1	
Diervilla lonicera	Northern bush-honeysuckle	G5	S3	
Dipodomys ordii	Ord's kangaroo rat	G5	S2	NIAC*; Special concern (1995)
Dodecatheon conjugens	Cylindric-fruited shootingstar	G5	S3	
Dodecatheon conjugens var *conjugens*	Bonneville shootingstar	G5, T?	S3?	
Dodecatheon conjugens var *viscidum*	Bonneville shootingstar	G5, T?	S3?	
Downingia laeta	Great basin downingia	G5	S1, S2	
Draba aurea	Golden whitlow-grass	G5	S1	
Draba cana	Hoary whitlow-grass	G5	S1	
Draba cinerea	Ashy whitlow-grass	G5	S1	
Draba reptans	Carolina whitlow-grass	G5	S2?	
Draba reptans var *stellifera*	Small whitlow-grass	G5, T?	S1, S2	
Drosera anglica	English sundew or oblong-leaved sundew	G5	S3	
Drosera linearis	Slenderleaf sundew	G4	S1	
Dryas drummondii	Yellow mountain-avens	G5	S1	
Dryas drummondii var *drummondii*	Yellow mountain-avens	G5, T?	S1	
Dryopteris cristata	Crested shield-fern	G5	S3	
Dryopteris filix-mas	Male fern	G5	S1	
Echinacea angustifolia	Narrow-leaved purple coneflower	G4	S3	
Egretta caerulea	Little blue heron	G5	S1B, SZN	
Egretta thula	Snowy egret	G5	S1B, SZN	
Elatine rubella	Mud purslane	G5	S2	
Eleocharis elliptica var *elliptica*	Flat-stemmed spike-rush	G5, T4?, Q	S2	
Eleocharis engelmannii	Engelmann's spike-rush	G4?	S2	
Eleocharis nitida	Neat spike-rush	G3, G4	S2	
Eleocharis parvula var *anachaeta*	Dwarf spike-rush	G5, T?, Q	S1	
Elodea bifoliata	Two-leaf waterweed	G4, G5	S2	
Elodea canadensis	Canada waterweed	G5	S2, S3	
Elymus elymoides	Bottle-brush	G5	S2	
Elymus glaucus	Smooth or blue wild rye	G5	S2	
Elymus interruptus	Various-glumed/ interrupted wild rye	G5	S2	
Elymus lanceolatus ssp *psammophilus*	Sand-dune wheatgrass	G5, T3	S2	
Eragrostis hypnoides	Creeping love grass	G5	S1, S2	
Erigeron compositus	Compound fleabane	G5	S3?	
Erigeron hyssopifolius	Hyssop-leaved fleabane	G5	S2	
Erigeron hyssopifolius var *hyssopifolius*	Hyssop-leaved fleabane	G5, T5?	S2	
Erigeron radicatus	Dwarf fleabane or tap-rooted fleabane	G3	S2	Not at risk (1996)

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

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Erigeron strigosus	White-top	G5	S2, S3	
Eriogonum cernuum var *cernuum*	Nodding umbrella-plant	G5, T?	S1	
Eriogonum pauciflorum	Few-flowered or branched umbrella-plant	G5	S2, S3	
Eriogonum pauciflorum var *pauciflorum*	Few-flowered wild buckwheat	G5, T5	S3	
Eriophorum scheuchzeri	Scheuchzer cotton-grass	G5	S1	
Eriophorum tenellum	Delicate cotton-grass	G5	S1	
Erynnis brizo brizo	Sleepy duskywing	G5, T5	S3	
Erynnis juvenalis	Juvenal's duskywing	G5	S3	
Euphrasia subarctica	Arctic eyebright	G5, Q	S1, S2	
Euphydryas editha hutchinsi	Edith's checkerspot	G5, T?	S3	
Falco mexicanus	Prairie falcon	G5	S3B, SZN	Not at risk (1996); NIAC (1982)
Falco peregrinus	Peregrine falcon	G4	S1B, SZN	Threatened (1999); endangered (1978)
Festuca brachyphylla	Alpine fescue	G5	S1, S2	
Festuca idahoensis	Idaho or bluebunch fescue	G5	S2	
Festuca rubra var *prolifera*	Proliferous red fescue	G5, T?	S1	
Gavia stellata	Red-throated loon	G5	S1B, SZN	
Gentiana andrewsii	Closed gentian	G5?	S1?	
Gentiana andrewsii var *dakotica*	Closed blue or blind gentian	G5?, T4, T5	S1	
Gentiana fremontii	Moss gentian	G4	S2	
Gentiana puberulenta	Downy or prairie gentian	G4, G5	S1	
Gentianopsis procera ssp *procera*	Narrow-leaved fringed gentian	G5, T?, Q	S2	
Geranium carolinianum var *sphaerospermum*	Carolina wild geranium	G5, T4?	S2, S3	
Geranium richardsonii	Wild white geranium	G4, G5	S2, S3	
Geranium viscosissimum	Sticky purple geranium	G5	S2	
Geranium viscosissimum var *viscosissimum*	Sticky purple crane's-bill	G5, T5?	S2	
Glaucopsyche piasus	Arrowhead blue	G5	S3	
Glyceria canadensis	Canada manna-grass or rattlesnake grass	G5	S1	
Goodyera oblongifolia	Giant rattlesnake-plantain	G5?	S2	
Grindelia squarrosa var *serrulata*	Tar weed	G5, T5	S1?	
Gulo gulo	Wolverine	G4	S3, S4	Special concern (1989)
Gymnocarpium jessoense ssp *parvulum*	Limestone oak fern	G5, T4	S2, S3	
Halimolobos virgata	Slender mouse-ear cress	G4	S1	Endangered*; Threatened (2000); endangered (1992)
Hedeoma hispida	Rough pennyroyal	G5	S3	
Helianthus tuberosus	Jerusalem artichoke	G5	S2	
Heliopsis helianthoides	Ox-eye	G5	S1	
Heliopsis helianthoides var *occidentalis*	Rough ox-eye	G, T?	S1?	
Heterodon nasicus	Western hognose snake	G5	S3	
Heuchera parvifolia var *dissecta*	Cut- or small-leaved alumroot	G5, T?, Q	S1	
Hieracium albiflorum	White-flowered hawkweed	G4, G5	S, S2	
Hiodon tergisus	Mooneye	G5	S3	
Hordeum brachyantherum ssp *brachyantherum*	Meadow wild barley	G5, T?	S1	
Huperzia porophila	Rock club-moss	G4	S1	
Huperzia selago var densa	Mountain or northern club-moss or fir-moss	G5, T?	S1	
Hutchinsia procumbens	Prostrate alpen-cress	G5	S2	
Hybognathus hankinsoni	Brassy minnow	G5	S3, S4	
Hymenopappus filifolius	Tufted hymenopappus	G5	S3	
Hymenopappus filifolius var *polycephalus*	Tufted or fine-leaf hymenopappus	G5, T4, T5	S3	
Hypoxis hirsuta	Eastern yellow stargrass	G5	S2	
Ichthyomyzon castaneus	Chestnut lamprey	G4	S3, S4	Special concern (1991)
Ictalurus melas	Black bullhead	G5	S3	
Ictalurus punctatus	Channel catfish	G5	S2, S3	
Ictiobus cyprinellus	Bigmouth buffalo	G5	S3	Special concern (1989)
Impatiens noli-tangere	Western or yellow touch-me-not	G?	S3, S4	
Iris versicolor	Blueflag	G5	S1	
Isoetes macrospora	Large-spored quillwort	G5	S1	
Isoetes x hickeyi	Hick's quillwort	HYB	S1	
Juncus albescens	Pale three-flowered rush	G5	S1	
Juncus confusus	Few-flowered rush	G5	S2	
Juncus ensifolius	Dagger or eqitant-leaved rush	G5	S2	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

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Juncus interior var *interior*	Inland rush	G4, G5, T?	S2	
Juncus nevadensis var *nevadensis*	Sierra rush/Nevada rush	G5, T?	S2	
Juncus saximontanus	Rocky mountain rush	G5	S1	
Juncus stygius ssp *americanus*	Moor or American bog rush	G5, T5	S1, S2	
Juncus tracyi	Mud rush	G5	S1	
Juniperus scopulorum	Rocky mountain juniper	G5	S1	
Lactuca biennis	Tall blue lettuce	G5	S2	
Lactuca ludoviciana	Western lettuce	G4, G5	S1	
Lanius excubitor	Northern shrike	G5	S1B, SZN	
Laportea canadensis	Canada wood nettle	G5	S2	
Lappula occidentalis var *cupulata*	Flat-spine sheepbur	G5, T5	S1?	
Lechea intermedia var *depauperata*	Impoverished pinweed	G5, T1	S1	Data deficient (1997)
Ledum palustre	Labrador-tea	G5	S2, S3	
Ledum palustre ssp *decumbens*	Narrow-leaved labrador tea	G5, T5	S2, S3	
Leersia oryzoides	Rice cut grass	G5	S1?	
Lemmiscus curtatus	Sagebrush vole	G5	S3	Not at risk (1996)
Lesquerella alpina	Alpine bladderpod	G5	S2, S3	
Leucophysalis grandiflora	Large white-flowered ground-cherry	G3?	S2	
Leymus cinereus	Giant wild-rye	G5	S1, S2	
Leymus mollis ssp *mollis*	Sea lyme-grass/American dune grass/dune wild rye	G5, T5	S2	
Lilaea scilloides	Flowering quillwort	G5?	S1	
Lilium philadelphicum var *andinum*	Western red lily/western wood lily	G5, T4, T5	S3, S4	
Lilium philadelphicum var *andinum f immaculata*	Immaculate lily	G5, TU, Q	S1	
Lilium philadelphicum var *philadelphicum*	Eastern red wood lily	G5, T4, T5	S1	
Limnodromus griseus	Short-billed dowitcher	G5	S1B,SZN	
Linanthus septentrionalis	Northern desert-gold or northern linanthus	G5	S1, S2	
Liochlorophis vernalis	Smooth green snake	G5	S3	
Liparis loeselii	Bog or yellow twayblade	G5	S1, S2	
Listera borealis	Northern twayblade	G4	S	
Listera cordata var *cordata*	Heart-leaved twayblade	G5, T5	S2	
Lithophragma glabrum	Bulbous star-flower/prairie star	G4, G5	S1	
Lithospermum ruderale	Woolly gromwell	G5	S1	
Lobelia dortmanna	Water lobelia	G4	S2, S3	
Loiseleuria procumbens	Alpine azalea	G5	S1	
Lomatium cous	Mountain meadow-parsley	G5	S1, S2	
Lomatium dissectum	Mountain wild parsnip	G3, G4	S1	
Lomatium dissectum var *multifidum*	Mountain wild parsnip	G3, G4, T?	S1	
Lomatium orientale	White-flowered meadow-parsley	G5	S1	
Lomatogonium rotatum	Marsh felwort	G5	S2	
Lonicera oblongifolia	Swamp fly honeysuckle	G4	S2	
Lotus unifoliolatus var *unifoliolatus*	Prairie bird's-foot-trefoil	G5, T5	S2	
Lupinus argenteus ssp *argenteus*	Silvery or perennial lupine	G5, T5	S3	
Lupinus pusillus ssp *pusillus*	Small lupine	G5?, T5?	S3	
Luzula acuminata	Hairy wood-rush	G5	S1, S2	
Luzula confusa	Northern or confusing wood-rush	G5	S1	
Luzula multiflora	Many-flowered wood-rush	G5	S2	
Lycopodium inundatum	Northern bog club-moss	G5	S1	
Lycopodium selago var *selago*	Mountain or northern club-moss or fir-moss	G5, T5?	S1	
Lycopodium sitchense	Alaskan club-moss	G5	S2	
Lynx rufus	Bobcat	G5	S3, S4	
Maianthemum racemosum ssp *amplexicaule*	False, clasping-leaved or fat Solomon's-seal	G5, T?	S1, S2	
Malaxis monophyllos var *brachypoda*	White bog adder's-mouth orchid	G4, T4	S1, S2	
Malaxis paludosa	Bog adder's-mouth orchid	G4	S1	
Marsilea vestita	Pepperwort	G5	S2, S3	
Megalodonta beckii	Water-marigold	G4, G5	S1, S2	
Megalodonta beckii var *beckii*	Water marigold	G4, G5, T4	S1, S2	
Melanerpes erythrocephalus	Red-headed woodpecker	G5	S1B, SZN	Special concern (1996)
Melica bulbosa	Onion-grass or bulbous melic-grass	G5	S1	
Mentzelia albicaulis	White-stemmed evening-star	G5	S1	
Mertensia lanceolata	Lance-leaved lungwort or mertensia	G5	S3	

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Mertensia lanceolata var *lanceolata*	Prairie bluebells	G5, T?	S3	
Milium effusum var *cisatlanticum*	Tall millet-grass	G5, T?	S1	
Mimulus glabratus var *jamesii*	Small yellow or Fremont's monkeyflower	G5, T5	S1	
Mimulus guttatus	Large yellow monkeyflower	G5	S2	
Mimulus ringens var *ringens*	Blue monkeyflower	G5, T5	S1	
Mimus polyglottos	Northern mockingbird	G5	S3, S4B, SZN	
Minuartia rubella	Boreal sandwort	G5	S2	
Mirabilis linearis	Narrow-leaved umbrella-wort	G5	S2	
Moehringia macrophylla	Large-leaved sandwort	G4	S2	
Monotropa hypopithys	American pinesap or false beech-drops	G5	S1, S2	
Monroa squarrosa	False buffalo grass	G5	S1	
Montia linearis	Linear-leaved spring-beauty	G5	S1	
Moxostoma anisurum	Silver redhorse	G5	S3, S4	
Muhlenbergia andina	Foxtail muhly	G4	S1	
Mustela frenata	Prairie long-tailed weasel	G5	S3, S4	Not at risk (1993)
Myosurus aristatus	Awned or mountain mousetail	G5	S2?	
Myosurus minimus	Least mousetail	G5	S2, S3	
Myosurus minimus ssp *montanus*	Bristly mousetail	G5, T?	S2?	
Myotis ciliolabrum	Western small-footed myotis	G5	S3B, S?N	
Myotis evotis	Long-eared myotis	G5	S3B, S?N	
Myriophyllum alterniflorum	Alternate-flowered water-milfoil	G5	S1	
Myriophyllum pinnatum	Green or pinnate water-milfoil	G5	S1	
Myriophyllum verticillatum	Whorled water-milfoil	G5	S3	
Najas flexilis	Flexible naiad	G5	S2	
Navarretia leucocephala	White-flower pincushion-plant	G4	S3	
Navarretia leucocephala ssp *minima*	Lesser navarretia	G4, T?	S3	
Notemigonus crysoleucas	Golden shiner	G5	S3, S4	
Nothocalais cuspidata	Prairie false-dandelion or cuspidate small lettuce	G5	S2	
Notropis blennius	River shiner	G5	S3, S4	
Notropis cornutus	Common shiner	G5	S3, S4	
Notropis stramineus	Sand shiner	G5	S3, S4	
Noturus flavus	Stonecat	G5	S2, S3	
Noturus gyrinus	Tadpole madtom	G5	S3	
Nymphaea leibergii	Small white water-lily	G5	S2	
Nymphaea odorata	American water-lily	G5	S1	
Oenothera caespitosa ssp *caespitosa*	Gumbo evening-primrose	G5, T5	S3	
Oenothera flava	Low yellow evening-primrose	G5	S3	
Onosmodium molle	Soft-hairy false gromwell	G4, G5	S2	
Onosmodium molle var *occidentale*	Western false gromwell	G4, G5, T4?	S2	
Onychomys leucogaster	Northern grasshopper mouse	G5	S3	
Oporornis agilis	Connecticut warbler	G4	S2B, SZN	
Orconectes virilis	Virile crayfish	G5	S3	
Oreoscoptes montanus	Sage thrasher	G5	S1B, SZN	Endangered (1992)
Orobanche uniflora	Small broomrape or one-flowered cancer root	G5	S1	
Oryzopsis canadensis	Canada mountain-ricegrass	G5	S2	
Osmorhiza berteroi	Chilean sweet-cicley	G5	S1	
Osmorhiza depauperata	Blunt-fruited sweet-cicely	G5	S3, S4	
Otus asio	Eastern screech-owl	G5	S3B, S2N	Not at risk (1986)
Otus kennicottii	Western screech-owl	G5	S1B, S1N	Data deficient (1995)
Oxytropis besseyi var *besseyi*	Bessey's locoweed	G5, T5?	S2	
Oxytropis campestris var *dispar*	Disparate late yellow locoweed	G5, T1, T3	S1	
Oxytropis lambertii	Stemless point-vetch	G5	S2	
Panicum virgatum var *virgatum*	Switch grass	G5, T5	S2	
Papilio machaon dodi	(Dod's) old world swallowtail	G5, T?	S3	
Papilio zelicaon	Anise swallowtail	G5	S3	
Parnassia glauca	Glaucous grass-of-parnassus	G5	S2	
Parnassia kotzebuei	Alpine grass-of-parnassus	G4	S1	
Parnassia parviflora	Small-flowered grass-of-parnassus	G4	S1	
Pedicularis groenlandica	Elephant-head or little red elephant	G4, G5	S1, S2	
Pedicularis labradorica	Labrador lousewort	G5	S2	
Pedicularis macrodonta	Purple or swamp lousewort	G4, Q	S2	
Pelecanus erythrorhynchos	American white pelican	G3	S3B, SZN	Not at risk (1987)
Pellaea gastonyi	Gastony's cliff-brake	G2, G4	S1	
Pellaea glabella ssp *occidentalis*	Western smooth cliff-brake	G5, T4	S2	
Percina maculata	Blackside darter	G5	S3, S4	
Periderida gairdneri	Squawroot	G5	S2	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Perideridia gairdneri ssp *borealis*	Northern Gairdner's squawroot or yampah	G5, T5	S2	
Perognathus fasciatus	Olive-backed pocket mouse	G5	S3	
Peromyscus leucopus	White-footed mouse	G5	S3, S4	
Phalaenoptilus nuttallii	Common poorwill	G5	S3B, SZN	Data deficient (1993)
Phegopteris connectilis	Long or narrow beech-fern	G5	S2	
Phleum alpinum	Mountain timothy	G5	S2	
Phlox alyssifolia	Blue wild or pointed blue phlox	G5	S2	Not at risk (1996)
Phoxinus eos	Northern redbelly dace	G5	S3, S4	
Phrynosoma hernandesi	Short-horned lizard	G5	S2, S3	Special concern (1992)
Picradeniopsis oppositifolia	Opposite-leaf false-bahia	G5?	S1	
Pinguicula villosa	Hairy butterwort	G4	S2, S3	
Pinguicula vulgaris	Common butterwort or bog-violet	G5	S2, S3	
Pinicola enucleator	Pine grosbeak	G5	S2B, S4N	
Piranga olivacea	Scarlet tanager	G5	S1B, SAN	
Plantago elongata	Narrow-leaved plantain	G4	S2, S3	
Plantago maritima	Seaside plantain	G5	S1	
Plantago patagonica	Pursh's plantain	G5	S2, S4	
Platanthera dilatata var *dilatata*	Scentbottle	G5, T5	S2	
Platanthera orbiculata	Large roundleaf orchid	G5?	S2, S3	
Platanthera x media	Hybrid bog orchid	HYB	S1	
Platygobio gracilis	Flathead chub	G5	S3, S4	
Poa alpina	Alpine blue grass	G5	S1	
Poa arctica ssp *arctica*	Arctic blue grass	G5, T?	S1	
Poa lanata	Lanate blue grass	G5	S1	
Polanisia dodecandra ssp *dodecandra*	Clammyweed	G5, T?	S1	
Polanisia dodecandra ssp *trachysperma*	Large clammyweed	G5, T?	S2	
Polygala alba	White milkwort	G5	S3	
Polygala paucifolia	Pink fringed milkwort; bird-on-the-wing	G5	S2, S3	
Polygala senega	Seneca snakeroot	G4, G5	S3, S4	
Polygala verticillata	Whorled milkwort	G5	S1	
Polygala verticillata var *isocycla*	Whorled milkwort	G5, T5	S1	
Polygonatum biflorum var *commutatum*	Great or common Solomon's seal	G5, T5	S2	
Polygonia gracilis zephyrus	Hoary comma	G5, T5	S3	
Polygonum polygaloides ssp *confertiflorum*	Dense-flowered or Watson's knotweed	G4, G5, T3, T4	S2	
Polygonum punctatum var *confertiflorum*	Dotted water smartweed or punctate knotweed	G5, T5	S1	
Polygonum scandens var *scandens*	Climbing false buckwheat	G5, T5	S2	
Polygonum viviparum	Alpine bistort	G5	S1, S2	
Pontia protodice	Checkered white	G4	S2	
Populus angustifolia	Narrowleaf cottonwood	G5	S1	
Populus x brayshawii	Hybrid cottonwood	HYB	S1	
Potamogeton amplifolius	Large-leaved pondweed	G5	S1	
Potamogeton epihydrus	Ribbon-leaf pondweed	G5	S2, S3	
Potamogeton obtusifolius	Blunt-leaved pondweed	G5	S2	
Potamogeton pusillus var *tenuissimus*	Berchtold's pondweed	G5, T5	S2	
Potamogeton robbinsii	Flatleaf or Robbin's pondweed	G5	S2	
Potamogeton strictifolius	Upright narrow-leaved pondweed	G5	S2	
Potentilla diversifolia	Mountain meadow cinquefoil	G5	S1	
Potentilla hookeriana ssp *chamissonis*	Hooker's creeping cinquefoil	G4, T?	S1	
Potentilla hookeriana ssp *hookeriana*	Hooker's creeping cinquefoil	G4, T?	S1	
Potentilla multifida	Cut-leaved cinquefoil	G5	S2	
Potentilla nivea var *pentaphylla*	Five-foliolate cinquefoil	G5, T4	S2	
Potentilla paradoxa	Bushy or strange cinquefoil	G5	S2, S3	
Potentilla pensylvanica var *litoralis*	Smooth or shore cinquefoil	G5, T4, T5	S2, S3	
Prenanthes alba	White lettuce	G5	S2	
Primula mistassinica	Bird's-eye primrose	G5	S3	
Prunella vulgaris	Lance-leaved heal-all	G5	S1	
Prunella vulgaris ssp *lanceolata*	Self-heal	G5, T5	S1	
Prunus americana	American plum	G5	S2	
Prunus pumila var *besseyi*	Sand or dwarf cherry	G5, T3, T5	S1	
Psilocarphus elatior	Tall woolly-heads	G4Q	S1, S2	Special concern (AB,SK) endangered (BC)
Pterospora andromedea	Pine-drops	G5	S1	
Puccinellia distans ssp *hauptiana*	Haupt's alkali-grass	G5, T3, T4	S2	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Puccinellia lemmonii	Lemmon's alkali-grass	G4	S1?	
Puma concolor	Cougar	G5	S2, S3	Data deficient (1998); eastern population - endangered
Pyrola grandiflora	Arctic wintergreen	G5	S1	
Rangifer tarandus	Barren-ground caribou	G5	S3	Special concern (1984)
Rangifer tarandus caribou	Woodland caribou	G5, T4	S3	Boreal population - threatened (2000)
Ranunculus cardiophyllus	Heart-leaved buttercup	G4, G5	S1, S2	
Ranunculus hyperboreus	Northern buttercup	G5	S1	
Ranunculus inamoenus	Graceful buttercup	G5	S1	
Ranunculus inamoenus var *inamoenus*	Graceful buttercup	G5, T5	S1	
Ranunculus pedatifidus var *affinis*	Northern buttercup	G5, T5	S2?	
Rhinanthus minor	Yellow-rattle	G5	S2, S3	
Rhinichthys atratulus	Blacknose dace	G5	S3, S4	
Rhus glabra	Smooth sumac	G5	S1	
Rhynchospora alba	White beaked-rush	G5	S2, S3	
Rhynchospora capillacea	Hair-like beaked-rush	G5	S2	
Rhynchospora fusca	Sooty beaked-rush	G4, G5	S1	
Ribes aureum var *aureum*	Golden current	G5, T?	S2	
Ribes oxyacanthoides ssp *setosum*	Bristly gooseberry	G5, T4, T5	S2	
Rorippa curvipes	Curved yellow-cress	G5	S2, S3	
Rorippa curvipes var *truncata*	Blunt-leaved yellow-cress	G5	S2, S3	
Rorippa tenerrima	Slender yellow-cress	G5	S1	
Rosa blanda	Smooth wild rose	G5	S1, S2	
Rosa x dulcissima	Hybrid rose	HYB	S1	
Ruppia maritima	Beaked ditch-grass or widgeon-grass	G5	S2	
Sagina nodosa ssp *borealis*	Knotted pearlwort	G5, T5	S2	
Salix arctophila	Arctic willow	G5	S2	
Salix brachycarpa var *psammophila*	Sand-loving barrenground willow	G5, T2, T3	S2, S3	Special concern (2000)
Salix planifolia ssp *tyrrellii*	Tyrrell's willow	G5, T2	S2	Not at risk (1999)
Salix reticulata	Net-leaf willow	G5	S2	
Salix silicicola	Felt-leaved willow	G2, G3	S2, S3	Special concern (2000)
Salix turnorii	Turnor's willow	G2	S2	Special concern (2000)
Salix x brachypurpurea	Hybrid willow	HYB	S1	
Sambucus racemosa	Red elderberry	G5	S3?	
Sambucus racemosa ssp *pubens*	Red elderberry	G5, T4, T5	S3	
Satyrium liparops aliparops	Striped hairstreak	G5, TU	S3	
Satyrodes eurydice eurydice	Eyed brown	G5, T4	S3	
Saxifraga occidentalis	Western or rhomboid-leaved saxifrage	G5	S1	
Saxifraga pensylvanica	Swamp saxifrage	G5	S1	
Schedonnardus paniculatus	Tumble grass	G5	S2, S3	
Scheuchzeria palustris ssp *americana*	American scheuchzeria	G5, T5	S3	
Scirpus atrovirens	Pale-green bulrush	G5?	S2	
Scirpus clintonii	Clinton's bulrush	G4	S1	
Scirpus pallidus	Pale bulrush	G5	S2	
Scirpus rollandii	Dwarf bulrush	G3, Q	S1	
Scirpus rufus	Red bulrush	G5	S2?	
Scirpus rufus var *neogaeus*	Red club-rush or bulrush	G5, T?	S2	
Scirpus subterminalis	Subterminal bulrush	G4, G5	S1	
Scutellaria lateriflora var *lateriflora*	Mad dog skullcap	G5, T5	S3	
Sedum lanceolatum ssp *lanceolatum*	Lance-leaf stonecrop	G5, T?	S3?	
Selaginella selaginoides	Low spike-moss	G5	S2	
Semotilus atromaculatus	Creek chub	G5	S3, S4	
Senecio integerrimus var *scribneri*	Scribner's entire-leaf ragwort	G5, T1, T3	S1	
Senecio plattensis	Prairie ragwort or groundsel	G5	S3, S4	
Senecio pseudaureus var *pseudaureus*	Western golden groundsel	G5, T?	S1?	
Senecio streptanthifolius	Northern groundsel	G5	S1, S2	
Shinnersoseris rostrata	Beaked annual skeleton-weed	G5?	S2	
Silene acaulis var *exscapa*	Moss campion	G5, T5	S2	
Silene antirrhina	Sleepy catchfly	G5	S1, S2	
Silene menziesii	Menzies' catchfly	G5	S3	
Silene menziesii ssp *menziesii*	White catchfly	G5, T?	S3	
Solidago x lutescens	Upland aster	HYB	S1?	
Sorbus scopulina	Western mountain-ash	G5	S2	
Sorex haydeni	Prairie shrew	G4	S3, S4	
Sorghastrum nutans	Indian-grass	G5	S1	
Sparganium fluctuans	Floating bur-reed	G5	S2	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Sparganium hyperboreum	Northern bur-reed	G5	S1	
Spea bombifrons	Plains spadefoot	G5	S3	
Spergularia canadensis var *occidentalis*	Western Canada sand-spurry	G5, T4?	S1	
Speyeria edwardsii	Edward's fritillary	G5	S3	
Sphyrapicus nuchalis	Red-naped sapsucker	G5	S1B, SZN	
Spiraea betulifolia var *lucida*	Shining-leaved meadow-sweet	G4, G5, T?	S2, S3	
Spiranthes lacera var *lacera*	Northern slender ladies'-tresses	G5, T5	S2, S3	
Spiza americana	Dickcissel	G5	S1B, SZN	
Splachnum luteum	Yellow collar moss or fairy parasols	G3	S3?	
Splachnum rubrum	Red collar moss	G3	S3?	
Sporobolus heterolepis	Northern or prairie dropseed	G5	S3	
Sporobolus neglectus	Small, annual or puffsheath dropseed	G5	S1	
Stellaria longipes ssp *arenicola*	Sand chickweed	G5, T3	S3	
Stellaria longipes var *subvestita*	Hairy long-stalked stitchwort	G5, T?, Q	S2	
Stephanomeria runcinata	Runcinate-leaved skeleton-weed	G5	S1, S2	Not at risk (1996)
Sterna caspia	Caspian tern	G5	S2B, SZN	Not at risk (1999); special concern (1978)
Stipa richardsonii	Richardson's speargrass	G5	S2	
Storeria occipitomaculata	Redbelly snake	G5	S3	
Streptopus amplexifolius var *amplexifolius*	Clasping-leaf twisted-stalk	G5, T5	S2, S3	
Strix nebulosa	Great gray owl	G5	S3B, S N	Not at risk (1995)
Strix varia	Barred owl	G5	S3B, S2N	
Suaeda moquinii	Shrubby seepweed	G5	S1	
Subularia aquatica	Water awl-wort	G5	S2, S3	
Subularia aquatica var *americana*	Water awl-wort	G5, T5	S3	
Surnia ulula	Northern hawk-owl	G5	S3B, S5N	Not at risk (1992)
Sylvilagus floridanus	Eastern cottontail	G5	S3	
Tanacetum bipinnatum	Lake Huron tansy	G5	S2, S3	
Tanacetum bipinnatum ssp *huronense*	Lake Huron tansy	G5, T4, T5	S2, S3	
Taraxacum officinale	Dandelion	G5	S2, S5	
Taraxacum officinale ssp *ceratophorum*	Horned dandelion	G5, T5	S2	
Taxidea taxus	Badger	G5	S3, S4	Not at risk (2000); NIAC (1979)
Tetraneuris acaulis	Stemless tetraneuris or rubberweed	G5	S1	
Tetraneuris acaulis var *acaulis*	Stemless tetraneuris or rubberweed	G5, T5	S1	
Teucrium canadense var *occidentale*	Hairy germander	G5, T5?	S2	
Thalictrum occidentale	Western meadow-rue	G5	S1, S2	
Thalictrum occidentale var *occidentale*	Western meadow-rue	G5, T?	S1, S2	
Thelypteris palustris var *pubescens*	Marsh fern	G5, T5	S1	
Tofieldia pusilla	Small false-asphodel	G5	S1	
Torreyochloa pallida var *fernaldii*	Pale manna grass	G5?, T4, Q	S2	
Tradescantia occidentalis	Western spiderwort	G5	S1	Endangered*; Threatened (1992)
Triadenum fraseri	Marsh St. John's-wort	G4, G5	S1	
Trientalis europaea ssp *arctica*	Arctic starwort	G5, T5	S1	
Trillium cernuum	Nodding trillium or wake-robin	G5	S2, S3	
Trimorpha elata	Tall white fleabane	G4?	S2	
Tripterocalyx micranthus	Small-flowered sand-verbena or sand-puffs	G5	S1	Endangered*; Threatened (1992)
Trisetum spicatum	Spike trisetum or narrow false oats	G5	S2	
Trisetum wolfii	Beardless oats or wolf's trisetum	G4	S1	
Typha angustifolia	Narrow-leaved cattail	G5	S1	
Umbra limi	Central mudminnow	G5	S2, S3	
Utricularia cornuta	Horned bladderwort	G5	S2	
Utricularia minor	Lesser bladderwort	G5	S2, S3	
Verbena hastata	Blue vervain	G5	S1, S2	
Verbena urticifolia	White vervain	G5	S1	
Veronica serpyllifolia var *humifusa*	Northern thyme-leaved speedwell	G5, T5?	S1	
Viburnum lentago	Nannyberry	G5	S2	
Viola bicolor	Field pansy	G5	S1?	
Viola blanda var *palustriformis*	Large-leaf white violet	G4,G5,T4,T5	S1?	
Viola conspersa	American bog violet	G5	S1	
Viola labradorica	Labrador violet	G5	S1	

CONSERVATION DATA CENTRE'S SPECIES OF CONCERN IN SASKATCHEWAN

(*Note: see end of appendix for description of rank and status codes)

Scientific Name	Common Name	Global Rank	Provincial Rank	Provincial*/ COSEWIC Status
Viola macloskeyi ssp *pallens*	Northern or sweet white violet	G5, T5	S1	
Viola pedatifida	Crowfoot, larkspur or purple prairie violet	G5	S3	
Viola pubescens	Downy yellow violet	G5	S1?	
Viola pubescens var *leiocarpon*	Smooth yellow violet	G5, T5	S1	
Viola selkirkii	Great-spurred or Selkirk's violet	G5?	S2, S3	
Viola septentrionalis	Northern blue violet	G5	S1?	
Viola sororia	Downy blue violet	G5	S1?	
Vireo flavifrons	Yellow-throated vireo	G5	S2B, S3N	
Vulpes velox	Swift fox	G3	S1	Endangered*; Endangered (2000); endangered (1998); extirpated (1978)
Vulpia octoflora	Six-weeks fescue	G5	S2	
Wolffia arrhiza	Rootless water-meal	G5	S1	
Woodsia alpina	Alpine or northern cliff fern	G4	S1	
Woodsia glabella	Smooth woodsia	G5	S2	
Woodsia oregana	Western cliff fern	G5	S2	
Woodsia oregana ssp *oregana*	Oregon woodsia	G5, T4?	S2	
Woodsia scopulina	Rocky mountain woodsia	G5	S1	
Woodsia x *abbeae*	Hybrid (sterile triploid)	HYB	S1	

* Provincial Status

PROVINCIAL AND COSEWIC RANK DEFINITIONS

The following are standard codes and modifiers that are used in provincial and global status designations. It is necessary to read the individual letters to interpret meanings, except for HYB (hybrid of species), SYN (synonym) and RF (falsely reported in province).

Examples:

SZN = Saskatchewan (S), no conservation concern (Z), migratory species (N)
SEC = Saskatchewan (S), exotic species (E), species exists only in captivity or cultivation (C)
SRF = Saskatchewan (S), falsely reported but error persists in the literature (RF)
S5B = Saskatchewan (S), very common (5), migratory species (B)
G5 = global (G), very common (5)

Codes and Modifiers

A - accidental or casual in the province, including species (such as birds or butterflies) recorded infrequently that are far outside their range
B - for a migratory species, rank applies to the breeding population in the province
C - species presently exists in the province only in captivity or cultivation
E - exotic species established in the province, may be native to nearby regions
H - historical occurrence but without recent verification (e.g., within 20 years)
HYB - hybrid of species
N - for a migratory species, rank applies to the non-breeding population in the province
P - potentially exists in the province but no occurrences reported
Q - taxonomic difficulties, more information needed
R - reported in province but lacks documentation which would provide a basis for accepting or rejecting the report (e.g., misidentified specimen)
RF - falsely reported for the province but the error persists in the literature
SYN - synonym: element reported as occurring in the province, but the province does not recognize the taxon
T - indicates uncertainty in the taxonomy (e.g., is the variety or subspecies designation valid?)
U - status uncertain in Saskatchewan, because of limited information
X - believed to be extinct or extirpated
Z - no practical conservation concern since there are no mappable and predictable occurrences (migrants)
? - not yet ranked in Saskatchewan

Note:

G - refers to global, a range-wide rank
S - refers to sub-national or, in our case, within Saskatchewan
N - refers to national rank or, in our case, in Canada

PROVINCIAL STATUS DEFINITIONS

The following table explains the meaning of the different ranks, which are part of the provincial status system.

Rank	Status	Definition	Comments
1	Extremely Rare	5 or fewer occurrences in Saskatchewan	Critically imperiled; may be especially susceptible to extirpation** or very few remaining individuals because of some factor of its biology
2	Rare	6 to 20 occurrences in Saskatchewan or few remaining individuals	Imperiled; may be susceptible to extirpation** because of some factor of its biology
3	Rare - Uncommon	21 to 100 occurrences in Saskatchewan; may be rare and local throughout province or may occur in a restricted provincial range (may be abundant in places)	Vulnerable; may be susceptible to extirpation** by large scale disturbances
4	Common	More than 100 occurrences; generally widespread and abundant, but may be rare in parts of its range	Apparently secure but may be of long-term concern
5	Very Common	More than 100 occurrences; widespread and abundant, but may be rare in parts of its range	Demonstrably secure

***Extirpation refers to the disappearance of a species in a particular region.*

COSEWIC STATUS DEFINITIONS

The following table explains the COSEWIC status system.

COSEWIC Status	Definition
Special Concern	A species of special concern because of characteristics that make it particulary sensitive to human activities of natural events
Threatened	A species likely to become endangered if limiting factors are not reversed
Endangered	A species facing imminent extirpation or extinction
Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere
Extinct	A species that no longer exists
NIAC (Not in any category)	A species whose status has been reviewed by COSEWIC and is considered secure
Insufficient Info.	A species whose status remains uncertain due to insufficient information

Status definitions, as determined by COSEWIC.
Data Source: Conservation Data Centre, Saskatchewan Environment.

GLOSSARY

Acid deposition - the process by which acids are deposited, either by wet deposition in the form of rain, snow, sleet, hail or fog or as dry deposition in the form of particulates such as fly ash, sulphates, nitrates, or as gases like sulphur dioxide and nitrogen oxide.

aquaculture - the managed production of fish under controlled conditions.

aquifer - stratum or zone beneath the earth's surface which contains groundwater.

bentonite - A soft plastic light-colored clay formed by chemical alteration of volcanic ash, commonly used in drilling mud. Bentonite swells considerably when exposed to water.

biodiversity (biological diversity) - refers to the wealth of life forms on earth, including plants, animals, micro-organisms, the genes they possess and their habitats.

bog - a plant community on wet, very acid peat.

boreal forest - consists of a vegetation type dominated by coniferous trees, especially black and white spruce, balsam fir or larch, interspersed with deciduous trees such as birch and aspen.

carbon sequestration - the provision of long-term storage of carbon in terrestrial or aquatic ecosystems, or underground, so that the buildup of carbon dioxide (a major greenhouse gas) concentration in the atmosphere will be reduced.

carbon sink - an area where the rate of carbon uptake by living organisms exceeds the rate of carbon release.

carcinogen - a chemical substance or type of radiation that can cause cancer in exposed animals or humans.

CFCs (chloroflorocarbons) - a family of manufactured gases composed of chlorine, florine, and carbon which, along with halons, are the main cause of stratospheric ozone depletion. CFCs are used in refrigerators, air conditioners, dry cleaning agents, and foam products such as mattresses and insulation.

channelization - the straightening or dredging of a stream to make it straighter, deeper or shorter.

chinook - a warm, dry wind blowing down the eastern edge of the Rocky Mountains in winter, causing clear skies and a dramatic rise in temperature.

climate change - an alteration in measured quantities (e.g., precipitation, temperature, radiation, wind, cloudiness) within the climate system, which is significantly different from previous average conditions and is seen to endure - bringing about corresponding changes in ecosystems and socio-economic activity.

cogeneration - the combined production of electricity and useful heat (usually steam) which can be used for industrial purposes.

combustion - a rapid chemical reaction of fuel with oxygen that produces heat and light. The combustion of carbon fuels (wood, coal, natural gas, petroleum products) produces a mixture of exhaust gases that include water vapor, carbon dioxide, nitrogen and oxides of nitrogen.

coniferous - evergreen shrubs and trees characterized by needle-shaped leaves, cones and a resinous wood.

consultation - a formal or informal process to obtain public feedback, opinion or advice for decision-making.

coulee - a dry or intermittent stream valley, especially a long trench-like gorge that once carried meltwater from an ice sheet.

crustacean - invertebrate with a hard, external exoskeleton and mostly aquatic, including crabs, lobsters, shrimps, barnacles and woodlice.

deciduous - plants which shed their leaves or needles at a particular season, usually autumn.

dissolved oxygen - oxygen molecules that are dissolved in water, usually expressed in milligrams per litre (mg/L) or parts per million (ppm).

diversity - a measure of the number of species and their relative abundance.

ecological reserves - provincial Crown lands which are established to protect unique or representative parts of the natural environment to preserve biological diversity and provide areas in which to conduct scientific research and outdoor education.

ecoregion - broad integrated land area characterized by a unique combination of landscape, physiography and ecoclimate within the Ecological Land Classification (ELC) System.

ecosystem - a natural association of plants, animals, other organisms and non-living components, which function together to circulate nutrients and create a flow of energy.

ecosystem indicators - indicators which measure and track changes in the health of the ecosystem.

ecosystem-based management - the integrated management of natural landscapes, ecological processes, physical and biological components and human activities to maintain ecological health and integrity of an ecosystem.

ecotourism - tourism which involves travel to relatively undisturbed or uncontaminated natural areas with the specific objective of studying, admiring, and enjoying the scenery and wild plants and animals, as well as any cultural aspects found in these areas.

ecozone - the broadest level in a hierarchy of ecological units within the Ecological Land Classification (ELC) System, which are units of the Earth's surface with distinctive combinations of physical characteristics.

electrostatic precipitator - a device to control the release of particles from an exhaust into the atmosphere. An electric charge is applied to the particles, and the charge particles are then collected on the surface of oppositely charged plates.

emissions - polluted gases, particles, or liquids released into the atmosphere.

endangered - see species.

endemic species - a plant or animal that is confined to a small area, or is very limited in geographic distribution.

epidemic - a disease that affects many individuals within a community at about the same time, with a sudden onset and rapid spread.

eutrophic - see tropic state.

evapo-transpiration - the movement of water from the soil and plant communities to the atmosphere by evaporation of water from the soil and transpiration of water by plants.

ex situ - outside of original habitat.

exotic - describes a species not native to a given area, introduced from elsewhere.

extinct - see species.

extirpated - see species.

fen - land covered wholly or partially with slowly moving water, but producing sedge, coarse grasses, or other aquatic plants and/or slightly acidic peat.

fescue - an area of grassland that is dominated by the grass species rough plains fescue.

Fish and Wildlife Development Fund Lands (FWDF lands) - lands acquired either through purchase or through donations of land by private individuals for "wildlife refuges" under the Wildlife Development Fund Program. This program conserves and improves critical habitat primarily for white-tailed deer, as well as other important game and endangered species.

forage - the leaves and stems of crops harvested as hay for animal feed. These crops are often perennial, e.g. alfalfa, clover, brome grass, wheat grass.

fuel load - the ovendry weight of combustible materials per unit area, expressed in kilograms per cubic metre, tones per hectare and tons per acre.

greenhouse gases - gases such as carbon dioxide, methane, chlorofluorocarbons, nitrous oxide and water vapor that trap heat in the Earth's atmosphere and contribute to global warming.

groundwater - that part of the subsurface water that is the zone of saturation, including underground streams.

halons (brominated fluorocarbons) - manufactured chemicals that play a major role in ozone depletion, along with CFCs; uses included specialized fire extinguishers.

hectare - one hectare is the equivalent of 10,000 m^2 (0.01 km^2) or 2.471 acres. A hectare could also be considered the area of slightly less than three Canadian football fields.

herbicide - substances used to kill unwanted plants which compete with a crop for sunlight, nutrients and water.

hydrocarbons - any of a class of compounds consisting of only carbon and hydrogen.

invertebrates - animals without backbones.

joule - a unit of energy equal to the work done by a force of one Newton over a distance of one metre in the direction of the force.

leachate - solution formed when water percolates through a permeable medium. In some cases, the leachate may be toxic or carry bacteria when derived from solid waste.

leaching - the removal of the soluble constituents of soil materials through percolating waters, and the transport of such constituents in solution.

lentil - a leguminous plant, the seeds of which are used as food.

lichen - a symbiotic organism created by the association of a fungus with an algae.

limiting factor - the dominant factor that restricts the continued reproduction of a spread of a particular species. The factor may be a physical restraint such as a light or a chemical substance such as an essential nutrient.

marsh - wet, or periodically wet, area, with aquatic and grass-like vegetation and no peat formation.

mean annual temperature - average yearly temperature.

micron - 39.37 millionths of an inch, or 0.001 millimetre.

mollusc - member of a diverse group of invertebrates, including snails and clams, which are mostly aquatic and covered with an external calcium carbonate shell.

montane - describes species associated with or growing in mountain areas.

neotropical - relating to regions of the tropics, including Central and South America, southern Mexico, West Indies and the Galapagos Islands.

non-point source - a source of atmospheric, aquatic or terrestrial pollution in which naturally occurring or human-created pollutants are discharged over a widespread area or from a number of small inputs, rather than from one distinct, identifiable source (point source).

outfitting - includes commercial hunting and fishing guiding services or a combination of guiding services and provision of equipment. Outfitters must be licensed by Saskatchewan Environment.

ozone layer - an area of the stratosphere, between about 20-50 km above the Earth, where the intensity of short-wavelength ultraviolet light from the sun is sufficiently high to convert normal diatomic oxygen to ozone. The ozone layer provides protection to plant and animal life on the surface of the Earth as it absorbs ultraviolet light that may be damaging to genes.

particulates - fine liquid or solid particles such as dust, smoke, mist, fumes or smog found in the air of emissions.

partnerships - a cooperative, collaborative alliance between stakeholders in a non-legal arrangement used to improve and build relationships and achieve common goals.

pathogen - a disease-inducing organism or abiotic (non-living) agent.

PCB - organic compound made up of polychlorinated biphenyls, which are carcinogenic.

peat - vegetable matter partly decomposed in wet acid conditions to form a brown deposit like soil.

permanent cover - former cropland converted to perennial forage and/or trees with some commitment to maintain the cover.

pesticide - substances such as herbicides, insecticides, fungicides, nematocides and rodenticides, used to kill unwanted pests.

phytoplankton - microscopic plants, such as algae, suspended in aquatic environments.

point source - a static, identifiable source of air, soil or water pollution.

Precambrian - geologic time from the beginning of the Earth to the beginning of the Cambrian period, when life first evolved, about 570 million years ago.

protected areas - designated provincial Crown lands under *The Parks Act*, or similar legislation, which protect and preserve site-specific cultural (i.e., archaeological, historical, paleontological) and natural areas of provincial significance.

provincial parks - parcels of Crown land which protect heritage resources within Saskatchewan.

radionuclides - radioactive chemicals that are usually naturally occurring and may be found in drinking water. Typical radionuclides include radioactive isotopes of uranium, thorium, radium, lead and polonium.

regeneration - renewal of a forest stand (i.e., establishment of new young trees) by natural or artificial means.

riparian - pertaining to anything connected with, or immediately adjacent to, the banks of a lake, river or other body of water.

silviculture - the theory and practice of controlling the establishment, composition, growth and quality of forest stands to achieve management objectives.

species - a group of individuals that share certain physical characteristics and are capable of producing fertile offspring.

- **endangered** - species on the verge of immediate extinction or extirpation.
- **extinct** - species that no longer exist anywhere.
- **extirpated** - species no longer found in the wild in Canada, although they may exist elsewhere.
- **threatened** - species likely to become endangered if the pressures from human or natural causes threatening them are not reversed.
- **vulnerable** - species at risk because of low numbers or restricted range; although not in immediate danger, they could be at any time.

stakeholders - the people or groups with a direct or indirect interest, or "stake," in an issue.

stewardship - judicious use and care of the Earth's resources.

summerfallow - land that has no crop for one year and is either tilled or chemically treated to control weeds.

surficial aquifer - an aquifer in a sand or gravel formation at or near the surface, with very little covering material.

tailings - waste material resulting from the washing, concentration or treatment of ground ore.

tillage - mechanical preparation of the soil for seeding, fallow or weed control.

trophic - the nutrients status of a waterbody determined by the average concentration of total phosphorous and the algae growth (productivity) that the phosphorous can sustain. The major trophic states are eutrophic (high), mesotrophic (medium) and oligotrophic (low).

vector - any organism or abiotic force capable of transferring a pathogen from one organism to another.

volatile organic compounds (VOCs) - compounds containing at least one carbon atom but excluding dioxide and carbon monoxide. VOCs are release during the combustion of gasoline, from various industrial processes and from the evaporation of liquid fuels, solvents and organic chemicals.

watershed - an elevated boundary separating tributaries that drain into different river systems.

wind chill - an index that combines the temperature and wind speed to determine how cold the wind makes it "feel."

zero tillage - a one-pass operation that places seed and fertilizer into an undisturbed seedbed, packs the furrow and retains adequate surface residues to prevent soil erosion.

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Abbreviations and Acronyms

Symbols/Measurements

C	Celsius
h	hour
ha	hectare
kg	kilogram
km	kilometre
kt	kilotonne
kPa	kilopascals
L	litre
m	metre
mg/L	milligrams per litre
mL	millilitre
mm	millimetre
Mt	megatonne
MW	megawatt
ng/J	nanograms per joule
µ	micron

Compounds

CaCl	calcium chloride
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
H_2O	water
NaCl	sodium chloride
Na_2SO_4	sodium sulphate
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
N_2O	nitrous oxide
O_3	ozone
K_2SO_4	potassium sulphate
SF_6	sulphur hexafluoride
SO_2	sulphur dioxide
So_x	sulphur oxides

Acronyms

API	Air Pollution Index
CAPMoN	Canadian Air Precipitation Monitoring Network
CDC	Conservation Data Centre
CEA	Canadian Electricity Association
CFCs	chlorofluorocarbons
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPI	Crop Protection Institute
CWD	chronic wasting disease
CWQI	Canadian Water Quality Index
DDT	dichlorodiphenyltrichloroethane
EOR	enhanced oil recovery
ESP	electrostatic precipitators
FFMC	Freshwater Fish Marketing Corporation
FMA	Forest Management Agreement
FWDF	Fish and Wildlife Development Fund
GDP	gross domestic product
GEMCo	Greenhouse Emissions Management Consortium
GERT	Greenhouse Gas Emission Reduction Trading
GHG	greenhouse gas
GMO	genetically modified organism
GWP	global warming potential
HFCs	hydrofluorocarbons
IEA	International Energy Agency
ILO	intensive livestock operation
IQUA	Index on the Quality of Urban Air
LIFAC	Lime Injection into the Furnace and Activation with Unreacted Calcium
NAWMP	North American Waterfowl Management Plan
NSR	nor satisfactorily restocked
NTU	nephelometric turbidity unit
OBO	Operation Burrowing Owl
OSB	oriented strandboard
PCBs	polychlorinated biphenyls
PCS	Potash Corporation of Saskatchewan
PFC	perfluorocarbons
PFRA	Prairie Farm Rehabilitation Administration
PM	particulate matter
RAN	Representative Areas Network
SAFRR	Saskatchewan Agriculture, Food and Rural Revitalization
SARA	*Species at Risk Act*
SARC	Saskatchewan Association of Rehabilitation Centres
SARM	Saskatchewan Association of Rural Municipalities
SARRC	Saskatchewan Association for Resource Recovery Corporation
SEM	Saskatchewan Energy and Mines
SERM	Saskatchewan Environment and Resource Management
SOE	State of the Environment
SPRR	Saskatchewan Parks and Renewable Resources
SPRC	Saskatchewan Parks, Recreation and Culture
SSTC	Saskatchewan Scrap Tire Corporation
SUMA	Saskatchewan Urban Municipalities Association
SWQI	Saskatchewan Water Quality Index
SWQO	Surface Water Quality Objectives
UV	ultraviolet
VOCs	volatile organic compounds
WHPA	*The Wildlife Habitat Protection Act*
WNV	West Nile virus